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WORKING

DRAWINGS & DESIGNS

ARCHITECTURE AND BUILDING

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Fully Illustrated with Woodcuts.

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David T. Samson

WORKING
DRAWINGS & DESIGNS
IN
ARCHITECTURE AND BUILDING;

WITH

ESSAYS ON VARIOUS SUBJECTS,

Richly Illustrated with Woodcuts.

BY

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AND

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(General Editor.)

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„ „ „ 29, „ 1st, 22 „ „ „ Fig. 13 „ 13*a*.
„ Third, „ 3, „ 1st, 13 „ „ „ "square of their length" read "square of their depth."
„ Fifth, „ 3, „ 2d, 21 „ „ „ Plate LXIV. read XXXIII.
„ Seventh, 2, „ 2d, 21 „ „ „ "as per end elevation, fig. 3, Plate XVII.," read "as per front elevation, fig. 1, Plate XVII."
„ Ninth, „ 2, „ 2d, 20 „ „ „ Plate XXXIII. read XXXVIII.
In Plate XXXIV., for "Plate LX." read "Plate XXXV."
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ERRATUM.

In par. 66, p. 13, Essay 5th, omit reference to Plate LXV. in 5th line of paragraph. This Plate, at the time the Essay was written, was intended to be given, but the extent of the work being subsequently curtailed, the intention was not carried out.

ON

THE PLANNING AND CONSTRUCTION

OF

WORKING MEN'S COTTAGES, AND DWELLING-HOUSES.

1. As our houses are made to live in, not to look at merely, it is essential that this their primary purpose should have the fullest consideration, while laying down the plans of their arrangement. In saying this, we but repeat a truism, one however which is not seldom lost sight of, if we are to judge by the monstrosities of "planning" which we frequently meet with. Where so much of the comforts of a house depends upon the arrangement of its apartments, it is impossible to be furnished with too many hints, so that the greatest possible amount of convenience may be obtained with the least possible expenditure of time and money. This same planning of a house is said jocularly to be as easy as farming, but that it is not so easy, nay anything but that, those know well, who have planned houses to suit the tastes and gratify the whims of their clients, and in planning have so often unfortunately, failed to please. Paraphrasing a well-known saying, it might be here stated, that he who employs himself for his own architect, has a fool for an assistant. Not here giving an opinion as to how much of truth—if any at all—there is in this; we certainly hold, that no man will be the worse of knowing what other men have known and done before him, and that the more hints he obtains while engaged in planning a house for himself, or a cottage for his workmen, the fewer mistakes he is likely to make. In this matter, at all events, the saying holds good, "in the multitude of counsellors there is safety." For in building, unlike many other affairs we undertake, mistakes once made cannot be rectified; a room made too small cannot well be enlarged, and if the experience of *living* in a place points out the inconvenience of any of its arrangements; we may regret but we cannot often amend them. In sitting down then to plan, as many of our readers will in those building mania days very likely do, it will be advantageous if they can gather round themselves a number of counsellors, so to speak, from whom they may obtain rough hints, if not sage counsel. A wise man may not adopt, but he will never object to receive, variety of advice in any matter which he is about to proceed with.

2. Many of the inconveniences which are often met with, alike in the cottages of the poor man, and the villas of the wealthy, arise, we venture to think, from what we term a wrong principle in "planning." The *form* of the house is often decided upon first, so that its external appearance shall be after a certain model or outline; the internal arrangement being thereafter decided on, certain parts or arrangements being crushed in so to speak; others for want of space being altogether left out. Hence in this way the house is found to contain apartments not only insufficient in dimensions but inconvenient in position—that is, inconvenient with reference to their juxtaposition to other apartments. Thus a scullery is often met with in a plan at a considerable distance from the kitchen; or a pantry, or store closet, in a part of the house where such a convenience is not required. Now we conceive that all these mistakes, and such as these, may be obviated by adopting a different mode of planning; that is, strictly carrying out the meaning of the term; and arranging all the apartments required in the house in the way most conducive to convenience and comfort, introducing as many "helps" to economical and tidy housewifery as possible—in this way the external appearance or outline of the house will be dependent on and caused by, not independent of, the prearranged or pre-determined internal conveniences. This we conceive to be what is meant strictly by the term "planning," not as necessarily opposed to, but rather in contradistinction to, what is termed "designing"—which latter calls into exercise the capability to ornament and add the beauty of form to the outline which the *plan* has created. Design, then, we look upon as being connected with the decoration; planning, with the arrangement of the apartments in the most convenient order.

3. But in planning a house, it is essential to know what is really required to make it comfortable and convenient. It seems somewhat unnecessary to point out this; but that it is not so easy a matter to know what *is* wanted in a house, and how and where to place it when we do know about it, is obvious enough on slight consideration, for by no means difficult a matter is it to find examples of houses, the arrangements of which good housewives will at once point out as defective in the extreme.

4. It might seem, at first sight, beneath the dignity of an architect to take counsel—while engaged in planning a house—from a housewife of an acknowledged taste; but in truth the advantages derivable from such counsel both to the livers in and the *workers about* the house, would be in no way contemptible or unworthy of notice. Not seldom indeed have we known where this housewifely counsel has been taken, and followed strictly out with marked benefit. There are few houses built—even model houses, falsely so called—the arrangements and conveniences of which could not be modified with advantage after taking a housewife—who knows what work there is in a house to do, and how to do it—through all its apartments, and asking her opinion about them; how far they are calculated to promote or to hinder economy and convenience. And it would certainly be the better way, if this counsel is worth taking at all, to take it *before* the house is built; and while simply it is projected upon paper. Doubtless it may be objected that there will be a difficulty in getting such a counsellor to understand the intricacies of a *plan*. But this same understanding of a plan by the female mind, is

not after all so difficult a matter as is, or might be, supposed. On the contrary, it will be found that a ready-witted appreciation of the merits or demerits of the plan will speedily follow upon its investigation by a female. Moreover, should there be a difficulty as to the understanding of the lines of the plan; a few calling cards arranged to represent the apartments of a house, and to show their juxtaposition, will call forth at once expression of approval of the contiguity of this apartment with that, or disapproval of this mode of entering a room, or of placing a scullery or kitchen. We do not urge an unimportant matter. Having all the work of the house to do, or at least to superintend, no one knows, or can know so well as a housewife the way in which this can best and quickest be done; and in how far the arrangement of the apartments of a house are calculated to arrest or retard the doing of this work. Questionless, as before hinted, all this may be beneath the dignity of an architect to do; but it need not, and should not—if his own best interests are consulted—be beneath the attention of the proprietor or the occupier of a projected house to look rigidly after. "In the multitude of counsellors there is safety," says the proverb; and in this same matter of house planning now under consideration, *female* counsellors are far from despisable.

5. As indicated in the title of our essay, we propose classifying our remarks upon the subject under two divisions—first, Cottages for Working Men; and second, "Dwelling-Houses," including in this term Villas, Suburban and Rural, Farm Houses; and buildings generally, of a class superior in point of accommodation and construction to the houses fitted for the working-classes.

DIVISION FIRST.—COTTAGES FOR WORKING MEN.

6. Under this division we propose to throw together, in addition to remarks of our own, a variety of "hints" obtainable from the recorded observations of authorities who have devoted their attention to this important subject. These hints coming from various parties will necessarily be stamped with the impression of various minds, and will in many instances be found materially to differ; but in the main points a remarkable unanimity will be found to exist. At all events, whether agreeing, or agreeing to differ, so to speak; these hints cannot fail to be of eminent service to those of our readers who may be interested in the question of improved house accommodation for our labouring population. For, as before hinted at, much will be learned by knowing what other men have thought on the various points of so important a subject. In addition, moreover, to those recorded "hints," which we propose gathering freely from a wide range of observation and research, we shall present a series of illustrations of "suggested" cottage arrangements, as well as of plans of cottages which are already constructed—analyzing these, and endeavouring to deduce from them warning as to arrangements which should be avoided, as well as recommendations of points which should be followed. For the pilot who points out the rock, performs a service as valuable, although in a different way, as he who leads the ship safely to the harbour. Beacons which point out obstructions, as shoals and sandbanks, are as useful as those which indicate the "fair-way." In giving the "hints" derived from the experience of others, or the remarks derived from our own, we do not intend to follow out any pretentiously systematic plan; we shall give them in somewhat desultory fashion, yet sufficiently systematic in arrangement to be easily referred to. Before beginning to "plan," there are certain points which should be considered. Amongst these are the following:—

7. *Form or outline of the Cottage.*—A cottage of which the outline is square can certainly be built for less money than one of which the outline is irregular; the space enclosed in the square cottage being larger, and of course capable of giving more accommodation, while the cost of roofing it is less. But from lack of the picturesque or pleasing element in the square cottage, this has been seldom adopted in constructions of the better class; irregularly outlined buildings, with projecting parts or "set off," being more generally adopted. But, although to a certain extent the square form is the cheapest, yet, nevertheless, the cottage having its outline or plan irregular is not so expensive as the advocates of the square form maintain it to be. Moreover, the irregularly outlined cottages present in their projections and recesses opportunities for making many pantries, closets, and the like, no small matter in a cottage. In a recent pamphlet by Dr. A. W. Wemyss of Pitkerry and Denbrae, near Cupar-Fife, this matter of "form" is gone into, here giving it may be suggestive.

> "It admits," he says, "of mathematical demonstration, that a rectangular building, formed by four equal sides (or square form) encloses a larger space than any other rectangular form, and that, as the square form is deviated from, a loss of space, in enclosed or superficial area, is the consequence, in rapid proportion as the length exceeds the breadth. Thus, a line one hundred feet in length, made to form a square of twenty-five feet in length by twenty-five feet in breadth, will contain or enclose a superficial area of 625 feet. But, if the same line be unequally divided, so as to form a rectangle, such as thirty-five feet long by fifteen broad, the area thus enclosed will only be 525 square feet, hence, by simply altering the form of the space or area (not the extent of the walls) one hundred square feet of it is lost. Now in the case of a house enclosed by any length of wall, and in a similar manner, the loss of space would be in the same proportion, which lost space might have been secured by being enclosed by the same length of wall, and for the same cost, if a different form (the square) had been adopted. This circumstance is obviously one of great importance in the economical construction of houses, although it does not seem to have been attended to as it deserves. It forms, however, a rule to be kept in view, where the greatest extent of space is desired at least cost. . . Any deviation from the square form leads to another problem in regard to this matter of much importance, namely, when two houses are built contiguously, i. e., so that one wall is common to both, to find the most economical length and breadth for the two. This will be found to be as three to two. But it is not expedient to apply this rule universally to the houses under consideration, for when they are above a certain size, its application might not suit so well for several of the details (such as the formation of the roof, the division of the house into apartments, the situation of the windows, fire-places, and offices) as a modification of it does. As a general rule, however, such a house should either be of a square form, or as near an approach to this as possible; or if two are built together, their form should be as nearly as possible in the proportions above specified."

8. *Two-storeyed or single-storeyed Cottages?*—This question should not be decided hastily, as if it involved no important points: whereas the truth is, that important points *are* involved which require serious consideration. One acquainted with the methods of arranging the accommodation of English and Scotch cottages, notices at once this striking difference between them. In England two-storeyed cottages are the rule, in Scotland decidedly the exception. In England great objection is made, and we think justly, to the mode of planning which gives a bed-room or the bed-rooms on the ground floor. Those who have lived in the two class of cottages in which bed-rooms are on and in which they are *not on* the ground floor, will, we venture to say, pronounce at once in favour of having the bed-rooms in the second storey. By arranging *all* the rooms of a house on the ground floor, two evils are involved,—first, an increase in the cost of roofing, as more ground-space is taken up,—and second, the almost certainty of having the rooms damp, to a greater or less degree, in consequence of the proximity to the ground. This second evil, we regret to say, is connected with an immense majority of one-storeyed cottages; and it is intensified in consequence of a plan of building to which we make pointed and special re-

ference in the paragraph immediately succeeding this. Refraining from now giving an absolute rule for the guidance of the planner, in deciding whether his cottage is to be one or two-storeyed, we would suggest, as a safe rule to be followed, that where the accommodation is required to be *more* than a "living-room," "bed-room," and "scullery," the extra accommodation should be included in a second storey. But in this case all the bed-rooms should be in the second storey. They will in this position be lighter, drier, and airier. As for "attic" or "garret" apartments, we put the consideration of their case out of court altogether; for we look upon them as wretched substitutes for a class and style of room which can be obtained at a cost very little more than that incurred by constructing the attics. All that is necessary is the slight vertical addition to the walls. Attics, cold in winter and hot in summer, inconvenient, as they are ugly in shape, height, and in general arrangement, are not really in any sense worth the money expended in making them. As the roof is required in any case, let it cover rooms properly formed and constructed; not shams and make-believes.

9. *Placing of Cottages squat upon the ground.*—On this point we should say, that this absurdity in building construction should never be perpetrated. Some absurdities are simply stupid, but innocent enough; some are mischievous; and to this latter class the absurdity quoted above belongs. Let the rule be—and this without *any* exception—that the ground floor of all apartments should be at a height of at least two—but all the safer and neater if three—steps above the ground level. It is almost impossible—nay, in many conditions of soil quite impossible—to keep a house free from damp when it is placed squat *upon* the ground, on a level with it. How infinitely worse must the condition of dampness be when the floor level is absolutely *below* that of the ground level; and you go *down* into the cottage in entering it, in place of going *up*. And yet, absurd and pernicious as this is, how often do we see it followed—more especially in the rural districts of Scotland. Questionless, the cost of building a cottage with the floor above the ground level is greater, to a small extent, than when the floor is on a level with the ground; nevertheless, where health is considered of importance, the extra outlay should never be grudged. But if economy is to be thought of before every other consideration, and dampness is thought nothing of where dearness comes into the field, all very good, —we do not say all very well,—only do not call—for in this case no good claim to the title exists—erections without floors above the level *improved* cottages. Many cottages newly built are honoured with the name of improved; but newness of construction does not always involve newness of arrangement. There are those who have this day, the credit of giving their labourers good cottage accommodation, because they have given them new cottages. But all that they have done is simply to give a fresh embodiment to stale and worthless arrangements—thus perpetuating the evils which they profess to combat, and for the assumed combating of which they get no small credit, albeit they in no wise deserve it. In not a few departments of cottage construction is this new embodiment of old errors met with; and in none perhaps more strikingly seen than in the department of

10. *Windows.*—Judging from the miserably small windows —if indeed they are worthy of the name—with which not a few cottages are provided, it is to be presumed that their designers have not thought that *light* in ample abundance is necessary either to promote health or to induce cleanliness and cheerfulness. No longer need the window-tax be pleaded as an excuse for insufficient light being given to cottages. But although that tax has long since been repealed, not a few buildings, erected under the new régime as regards the window-tax, are still, we regret to say, under the old régime as regards small —miserably small—windows. There is a vast deal of red-tapeism, so to speak, existing amongst the tradesmen who continue to use such defective appliances, if not also amongst proprietors who allow such mistakes to be perpetrated. "Our fathers," such may be said to be the form in which the excuse puts itself, "our fathers did it before us, are we wiser than they?" seems not seldom to be in their mind; and "wee" regulation windows, like many other regulation things, although fiercely denounced, hold on their way nevertheless. To put a window frame of a certain size in all cottages alike, seems to have been the rule in many districts—a rule with too few exceptions, unfortunately. The size of the room to be lighted, or the position of the window with relation to external objects, as a clump of trees, a rising bank, a wall, or the like, being evidently put out of mind altogether, as data from which to regulate the size of the window. We have said that light in abundance not only promotes health, but induces cleanliness and cheerfulness. But while many will promptly admit that light is a healthy thing, they do not or will not so readily see that light is inducive of cleanliness. But a little consideration will show that a dark or a dimly lighted cottage cannot be a clean one. Dirt, to become odious to the housewife, must be *seen;* once seen and not swept off, without hesitation we at once decide that the wretch who can allow dirt thus to have the rest of repose, is a slattern fit only to linger out a lazy life in a lightless cell, and in nowise worthy to be dignified with the high and honourable title of housewife. The darkest corners of a cottage are invariably the dirtiest; and what the eye sees not, in this case at all events, troubles not the mind: and we appeal to all good housewives if it is not likely to be the case, that careless cleaners are too glad of any excuse for neglected work to overlook the force of an argument such as this, "that they could not see to do it." Whether all this be correct or not, we willingly leave to the decision of competent housewives; but sure are we that a light house has a better *chance*—to put the case in its mildest form—to be kept regularly and rightly clean, than where it is dark. Dirt usually flies from the search of light as fire from water: this, however, must be taken with a reservation as "only in well-regulated houses." For to a certain class of the mind female, dirt does not appear in such hideous guise as it does to others; nay, so far from being hideous at all, it may be said that they like it. But this is quite a different point: tastes differ; and the proverb applies apparently in the matter of dust and dirt, as well as in other things. This, however, does not touch our main position, that a light house will likely be a clean one. On the importance of light as promotive of health, there cannot surely be two opinions. It is now admitted that the continued absence of light induces diseases absolutely peculiar to this condition of things. We see the effects of darkness in the half-developed vitality of vegetables grown in it. A light house, moreover, has always a cheering influence on the mind and spirits; while a dark one has invariably a depressing one; and mental influence over the physical condition of man plays too important a part in the animal economy to be lightly passed over. There may be some excuse for having small windows in old erections; there can or should be none for putting them in new erections. Let the supply of light be sufficient to lighten up all the corners of the room—those remote from as well as those near to the window.

11. *Cupboard or Press conveniences.*—Let the plan of the house embrace as many as possible of these conveniences. It is all very easy for well-to-do folks who live in fine houses to find fault with the careless habits of the poor in the matter of household tidiness. "Why don't they?" is the question asked, "why don't they put every thing in its proper place?" Very good, and in every way worthy of consideration; only,

in many cases, it involves a point strangely overlooked, namely, that the poor *have a place* to put things in—not by any means *always* the case—nay, we may say not by any means *often* the case; the truth being, perhaps, that as a rule the cottages of the poor are not provided with those conveniences by which alone household tidiness can be secured. It is self-evident, we venture to affirm, that things *must* be "littered," as the expressive phrase is, everywhere and anywhere in cottages where there is no special provision made for putting things away in proper and due order. Nothing is so easy as to find fault; and certainly there are many points in the household arrangements of the poor open to censure; but in this matter of neglect of the rule, "Every thing in its place," they are blamed where blame is not deserved: it should be remembered that every thing in its place *cannot* be attended to, unless there is a place for every thing. The one involves the other—a point not always remembered by those engaged in planning or erecting cottages.

12. *Provision Storage.*—This is another point in the arrangement of cottages which is generally left to itself, and which is but another way of saying, that it is generally overlooked and neglected. Yet is the alternative of no small importance to the poor, that if they have no place to put provisions in, they must either buy in no stock, or if they buy it, must see it wasted through bad storage. Ordinary presses or cupboards do not meet the requirements of the case so effectually as the *cellar* apartments so commonly met with in the houses of Lancashire. Failing this, let the provision store be next an outside wall; or better, let it project therefrom, so that a complete current of air may be established through it.

13. *Scullery or Wash-house.*—Aiding mightily the efforts of the good housewife in her attempts to keep the house orderly, is this same convenience; adding also to the attractions of home by getting rid of the annoyance of washing in the living room. "Habits of cleanliness and order," as we have in another place remarked, "can never be characteristic of the labouring classes so long as the structural conveniences —or rather inconveniences—are such as to prevent them having their houses 'clean and tidy;' and which have the effect of accustoming them to filth and disorder." It is a huge folly to look for habits of a superior order, where there is every inducement to the cultivation of, or at least the toleration of, those of an opposite kind. The "scullery" should be large enough to enable washing to be done; and if there is room for a small furnace and boiler, so much the better—a step higher in the rank of "healthy homes" will be attained. We look upon this facility for "washing," apart from the "living room," as a matter of great importance in dwelling-places for the labouring classes. Few but have *heard* of—and those are the lucky portions of *man*kind who have only *heard* —and many are they that have known, of the discomforts which the operations of a washing day invariably and unfailingly bring to a household. The evils thus arising need not here be stated; they have formed alike the burthen of "song" and of "complaint;" and we may add, have not unfrequently acted as an incentive to, or been hailed as an excuse by, the labouring man to leave his own fireside for the evils, but alas! attractive ones, of the public-house. Let every thing, then, be done to counteract such attractions, and to make a man's own fireside the brightest thing in his memory when he is absent from, and the greatest attraction when he is at his house. And this addition of a scullery and wash-house will in no small degree tend to make his home attractive, because it will tend to make it comfortable.

14. *Independent entrances to Bed-rooms.*—It is certainly not always easy in planning a cottage to provide this; but all attempts should be made to secure it if possible. The advantages in times of sickness are so obvious, not taking into account other considerations, as household tidiness, morality, &c., that it is deemed unnecessary here to advocate further the claims of this point to the notice of the "planner."

15. *Bed-rooms or Bed Closets?*—On this point the remarks of Dr. Kilgour, in his lecture 'On the Ordinary Agents of Life,' are so pregnant with meaning that we deem any of our own quite unnecessary:—

> "We are beginning to recover from the absurd plan of cramming our beds into small closets in order that they might be out of sight and out of the way. Architects a few years ago seemed to think that the public rooms could not be too large, nor the bed-rooms too small, provided only a dressing closet was attached. A third part of the twenty-four hours we spend motionless, and exhaling the rankest and most fœtid part of our cutaneous and pulmonary secretions, in a small and confined bed-room, in order that we may shiver and starve in a large room during the rest of the day that we remain in the house. How often has the physician to regret the confined bed-room in which his patient is placed? Often it is impossible to ventilate it by raising the window without risking the full draught of cold air on his patient. I have more than once seen the convalescent from fever cut off by pneumonia from being exposed to the currents of cold air from a window raised a little to refresh him or ventilate the room. Alcove beds are improper, from retaining the foul air. The bed should stand in the middle of the room, and not in a corner, yet so as not to be in the draught from door to window or chimney."

16. *Porch to Living Room.*—No living room should be entered at once from the street or road. It is essential that we should—so far as structural arrangements are capable of doing this—aid the labourer to economise his means. Now the economy of fuel cannot be secured in a house the main living room of which is subject to the biting blasts of winter blowing fiercely through the room, coming directly from the outside. "We have no doubt," as we have elsewhere said, "that if all the houses in some of our manufacturing towns had porches, or what is the same thing in effect, inner doors, a very large saving to the inhabitants in fuel would be the result. We do not write about a 'point of indifference' or one on which we have no practical knowledge; we have made it our business to know personally the inconveniences resulting from this arrangement of doors opening to a living room from the external atmosphere; and from knowing these, and hearing so often the complaints of the inhabitants, we cannot think it a 'point of indifference' which involves the alternative of personal suffering from cold or the outlay of a very much larger quantity of fuel than would be required if proper arrangements were made to prevent the great influx of air which must take place where the door opens to the external atmosphere. Other inconveniences arise from the want of a porch or window, not the least of which is the want of that domestic privacy so dear to the Englishman, resulting from the habit so much indulged in by the working classes of keeping the doors of their living room open during sultry weather. In the manufacturing districts it is quite impossible not to witness many domestic operations going on in the interior of the cottages while walking past them."

17. *Extent of Accommodation in Cottages.*—This will obviously depend upon a variety of circumstances so far as the maximum number is concerned; the important point to be decided is the *minimum* accommodation required, so as to secure at once the comfort of the inhabitants, and the requirements of morality. On this point the Association for Improving the Condition of Agricultural Labourers in Scotland has the following, which is suggestive:—

> "Some maintain that a kitchen and a bed-room, with pantry or milk house, is quite sufficient, and that to give more is an error, as a ploughman can only furnish one apartment. But very little furniture will suffice in a small bed-room. They must have the requisite number of beds, and it seems quite as easy to have them in separate rooms as to have two in the same room. All the addition, therefore, that is required

is a small table, a couple of chairs, and, if thought necessary, a small basin-stand. It is plain that if there is a large family living in such a house as that mentioned, namely, a room and kitchen, there cannot be a proper separation of the sexes. On the other hand, it is asserted that there should be *no* beds in the kitchen, and no fewer than four separate apartments,—one the kitchen or living room, a bed-room for the parents, and two smaller bed-rooms for the children, and this seems the proper method if there is to be a due separation of the sexes, and no beds in the kitchen. There is, however, a strong prejudice among the ploughmen themselves against removing the beds from the kitchen, and it may be worth while to consider whether something between these different methods might not answer the same purpose. By allowing *one bed only* in the kitchen, and having two bed-rooms besides, three separate sleeping apartments can be obtained (as in the former case) without violating the prejudices of the inhabitants so much as if the beds were entirely removed from the kitchen. This method is liable, however, to the objections urged against sleeping in the kitchen. Each house should also have a milk-house or pantry. A scullery (if properly used) will also be a great convenience for washing, &c., as by this means the kitchen may be kept in a much cleaner and more orderly state than it would otherwise be. To secure therefore the ends above mentioned, it appears that at least three apartments are necessary, two of these being used exclusively as sleeping apartments, the other the kitchen or living room for cooking, &c., and also as a sleeping apartment; and if the kitchen is used for cooking and eating only, four apartments will be required."

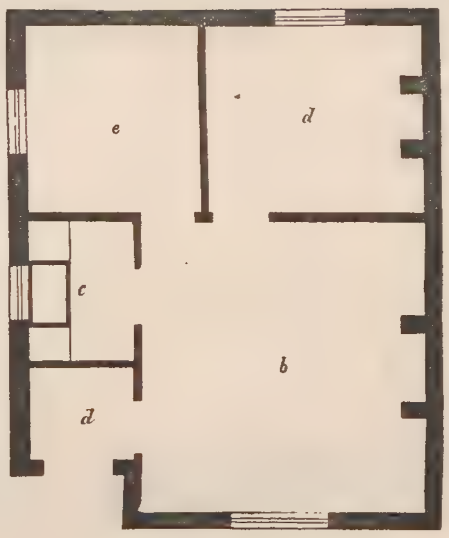
18. *Cottages all of one size.*—It certainly is a somewhat remarkable circumstance, that in planning cottages for the labourer, the idea has rarely occurred that as families varied in numbers, so should the cottages vary in size which are required for their accommodation. The following remarks by Dr. Watson are exceedingly valuable on this point:—

"The houses," he remarks, "for agricultural labourers upon a farm should not all be made of one size, as if by one stereotyped plan, without respect to the number of persons who may occupy them. The circumstances of these labourers differ so much, as to their families, that on all farms upon which there are a number of cottages, these should be of two or three different sizes. In this way the wants of the different families would be provided for, and no more. The houses might also be somewhat varied in their accommodations, in order that the best houses (containing superior accommodation), might form an object to be aspired to by superior workmen for good conduct and faithful service. To accommodate a man and his wife, for example, without a family, a kitchen or day-room, and one bed-room only, would be sufficient; while a man, with a mother, sister, or daughter to keep his house, would require two separate sleeping rooms; and a man with a wife and family of three or four children would require three sleeping places, being one for the parents, and one for the children of each sex. As a convenient division, therefore, for my present purpose, I divide the houses into three classes—each class having one, two, or three separate sleeping places respectively.

"To give farm servants larger houses than they require for themselves or their families is no advantage to them; because a large half-occupied house would be cold and uncomfortable; and it would be a loss to the proprietor, by putting him to unnecessary expense for building, upholding, and taxes; while he might, at the same time, be annoyed by the occupants of the houses taking in strangers or improper persons as lodgers. If it is admitted and settled, as it generally seems to be, that the size of the kitchen or day-room of a cottage should be about 12 feet square, or contain about 144 square feet of superficial area; and that a bed-room should be about 10 feet square, and contain from 90 to 100 square feet of area—it then follows that cottages of three different classes and sizes to which I refer should be of the following dimensions, viz.:—*Cottages of the First Class,* or smallest size, consisting of a kitchen or day-room, one sleeping apartment, and other suitable accommodations, will each require a space of square form enclosed by from 80 to 90 feet in length of outside walls. These walls being two feet in thickness, would enclose a proper area of from 260 to 350 square feet of surface, to be properly divided by partitions: *Cottages of the Second Class,* consisting of a kitchen, two sleeping rooms, and other suitable accommodation, will each require about 100 feet of outside wall; and *Cottages of the Third Class,* consisting of a kitchen, three sleeping rooms, and other accommodation, (required to be in proportion to the greater size of the houses,) will require about 110 feet of outside walls to enclose sufficient space. But if beds are to be placed in the kitchens, one sleeping place in each cottage will be saved, in which case the kitchen requires to be proportionably larger. These numbers may be varied a few feet more or less, according to the form of the house and the pleasure or taste of the proprietor; but when the most economical form is adopted, as already described, and the ceilings of the rooms are well elevated, walls of less extent will suffice, and still afford equally good accommodation. On this same point Mr. Stephens, in the 'Book of the Farm,' has the following sound remarks:—'The usual practice in building cottages for farm servants is to adopt a uniform plan upon which all are built. The practice is not founded on sound principle, nor even on expediency; because it implies that families, consisting of very different numbers, should nevertheless be accommodated within a similar space. Instead, therefore, of a family accommodating itself to the size of the cottage, the cottage ought to be adapted to the wants of the family; and there is no way of establishing this mutual understanding between cottages and their inmates, but by building them of different capacities for accommodation. This is the only rational course to pursue; and in pursuance of it, it is as easy to build a given number of cottages on different plans as on the same plan.'"

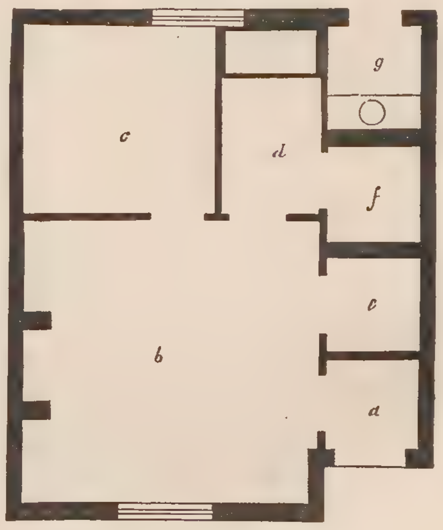
19. *Suggestive Plans of Cottages.*—Having in the preceding paragraphs gone somewhat fully into various points of importance, which should be well considered before commencing to lay down plans for cottages, we are prepared to present to the notice of our readers a few plans. These, as before stated, are not given as suggestive of good arrangements, but also of deficiencies and oversights. Fig. 1 is the sketch plan of a detached single-storeyed cottage, in which *d* is the porch, with space for a pantry; *c* the scullery; in this there is a slop stone placed near the window. The two bed-rooms *d e* are at the end, both being entered from the living room *b*. In fig. 2 we give the plan of one of a pair of single-storeyed cottages, in which *a* is the porch, *b* the living room, *c* the bed-room, *d* the scullery with pantry, *e* bed-closet in which is placed a fold-up bed, leaving the room clear during the day, *f* a store-closet,

Fig 1.



Plan of Cottage with Three Apartments.

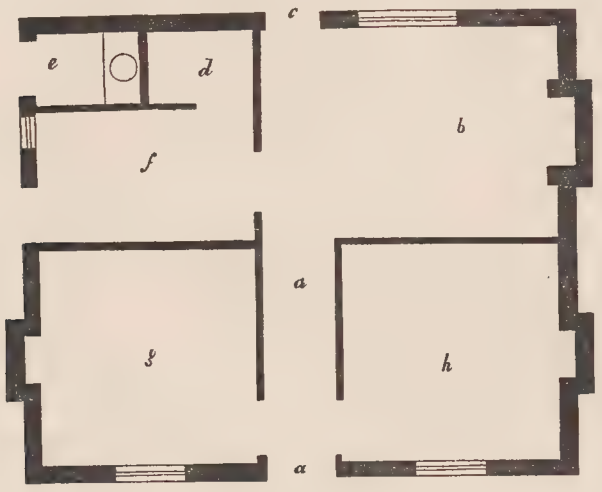
Fig 2.



Plan of a Cottage with Two Apartments.

g a water-closet or coal store. In fig. 3 we give the plan of a detached single-storeyed cottage, having superior accommodation to the two already given. In this there is a central passage *a a*, *b* living room with back-door *c*, *f* scullery or back kitchen, with store-closet and water-closet, *g h* bed-rooms.

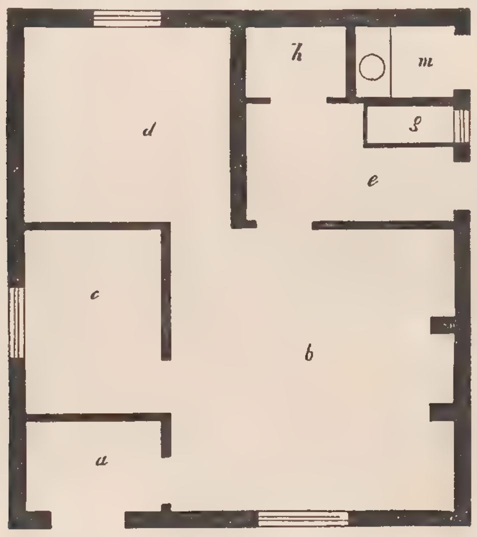
Fig. 3.



Plan of Cottage with Four Apartments.

20. In fig. 4 we illustrate the arrangement of a single cottage one-storeyed. The porch is at *a*, *b* the living room, *c* a lighted bed-closet entering from the living room *b*, *d* a bedroom, *e* scullery, *g* the slop-stone, *h* coal-cellar, *m* water-closet.

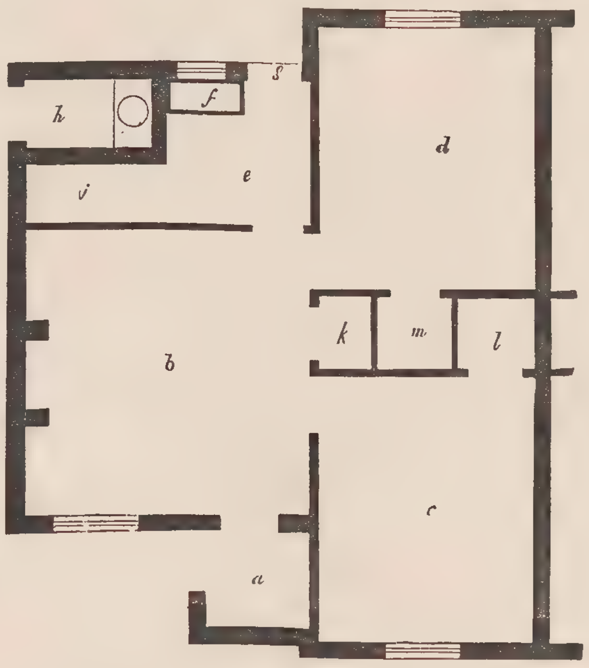
Fig. 4.



Plan of Single-Storeyed Cottage with Three Rooms.

21. In fig. 3, the accommodation is of a superior class to figs. 1 and 2. In these the bed-rooms and bed-closets are all entered from the living room. This is objectionable in cases of sickness; although it is but right to mention that, as a rule, the labouring population rarely object themselves to this, or to the want of a porch, &c., &c. It has been said by way of accounting for this, that they require to be educated so as to know and appreciate the advantages of such arrangements as separate bed-rooms for the different sexes—separate entrances in these bed-rooms, porches, &c. And certainly that is no good reason why the houses of the poor should not have such conveniences because they are not acquainted with them, and when made acquainted with, do not *at once* appreciate them. As well refuse to teach them to read and write, on plea that they do not wish to know, or do not appreciate the value of reading or writing. It is assuredly the better way to arrange the houses of the poor in the best way calculated to promote at once comfort, economy of time, and the cultivation of the moral and intellectual habits which are so well calculated to raise them in the social scale. And good household arrangements, whatever may be said to the contrary, do assuredly tend to raise the standard of living; and, in so doing, the status of "life" of the labouring classes inhabiting them. In fig. 5 *a* is the porch, *b* the living room, with scullery *e* entering from it; from the scullery the closet *j* is entered; *h* is the water-closet, *c d* bed-rooms *k l m* pantry-closets. In this plan, from the back door *g* being made to face the porch *a*, a thorough draft or current of air may be sent through, well ventilating the house. This, however, it is right to state, is considered an objection by some authorities, as it tends to keep up a perpetual current through the living room, keeping it cold in winter time.

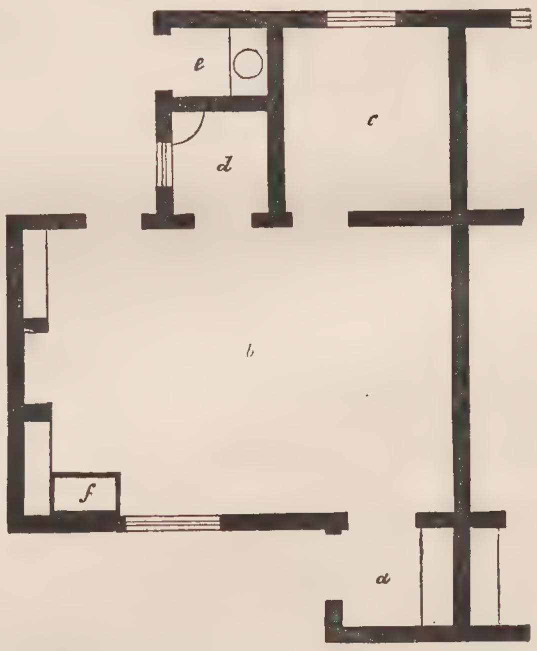
Fig. 5.



Plan of Single-Storeyed Cottage with Four Apartments.

22. In fig. 6 we give a plan of a single-storeyed cottage; *a* the porch, *b* the living room, *c* small bed-closet, *d* a pantry, *e* water-closet, *f* slop-stone in living room. This arrangement, we consider, embodies all the essential conveniences for a man with wife and one or two children. An improvement in this plan would be placing the slop-stone in the closet *d*, making this a scullery, dispensing with the water-closet *e*, and making the space occupied by it into that of a store-closet.

Fig. 6.



Plan of Single-Storeyed Cottage with Two Apartments.

23. In figs. 3, 4, 5, and 6, it will be perceived that all the fire-places are in outside walls; this is considered a great defect in a plan, and infinitely inferior to the method of having all the fire-places against inner walls, which retains the heat within the houses, and keeps the walls dry. This desideratum could be obtained in fig. 3 by placing the fire-places against the inner wall dividing the room *h* from *b*, and *g* from *f*. In fig. 4, the fireplace might be built on the wall dividing living room *b* from scullery *e*, just where the door is at present, this door being moved nearer to the outer wall. To fig. 5 the same remarks apply, and, by giving fire-places to the two bed-rooms *c d*, a decided improvement would be effected, these being built against the central wall dividing the two houses; for this plan is designed to be carried

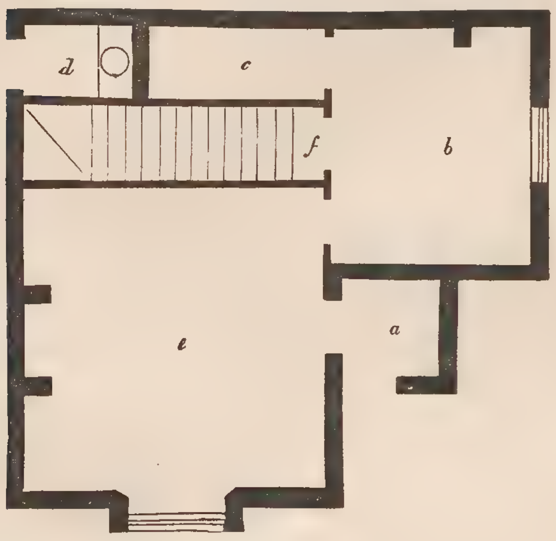
out in pairs. In fig 6, the fireplace ought to be placed in the wall exactly opposite to the point at which it now is.

24. In all of the plans now given, the water-closet or privy is made part of the arrangements; this will be gravely objected to by some, and where objections are held the space can be appropriated for other purposes—either to serve as additional closets, or to be added to the scullery. Thus in fig. 3 the privy *e* may be put to the closet *d;* or, as in figs. 5 and 6, may be made to enlarge the sculleries *e* and *d*. In all these plans, cupboard or press conveniences are pretty well provided.

25. The plans already given are single-storeyed, *detached* or built alone, as in figs. 3 and 4, or *semi-detached*, or in pairs, as in figs. 1, 2, 5 and 6. These latter, however, are equally well adapted to be built detached. We now proceed to give illustrations of plans of cottages with two storeys.

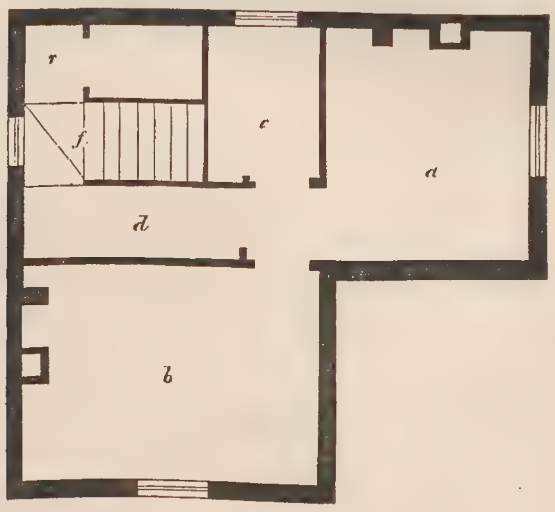
26. In fig. 7, the ground plan of a two-storeyed cottage, *a* is the porch, *e* the living room, *b* scullery or back kitchen with closet *c* off it, *d* privy, *f* stair to second or chamber floor. In fig. 8, the plan of chamber floor *a b* are bed-rooms, *c* bed-closet, *d* landing, *f* stairs, *r* linen closet. If this cottage is built in pairs, the privy will have to be entered from the back.

Fig. 7.



Ground Plan of Two-Storeyed Cottage with two apartments on floor

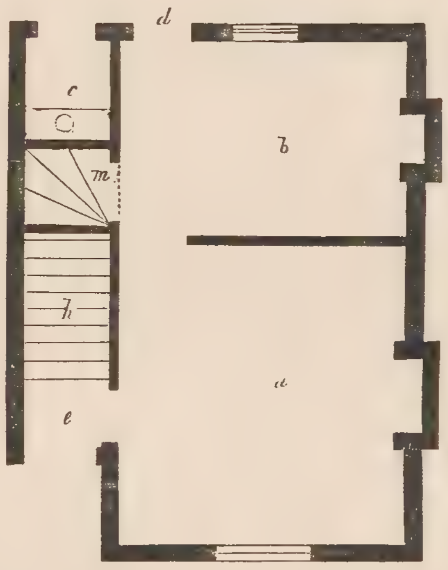
Fig. 8.



Chamber Plan of Two-Storeyed Cottage with three apartments on floor.

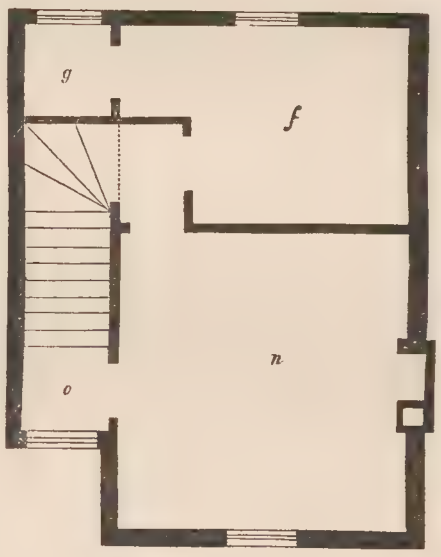
27. In the last plan, there is an objectionable feature in the stairs to the second floor having entrance and exit only through the two apartments *a* and *b*. In the cottage in fig. 9, a separate entrance is obtained to the stairs independently of the apartments. In fig. 9, *e* is the entrance, *a* living room, *b* scullery, with back entrance *d*, *c* privy, *m* closet under stairs entering from scullery *b*, *h* the staircase. In fig. 10, the chamber floor, *n f* bed-rooms, *o* a closet entering from front bed-room *n*, and *g* a closet entering from back bed-room *f*. This plan may either be built detached (single) or semi-detached (in pairs).

Fig. 9.



Ground Floor of Two-Storeyed Cottage.

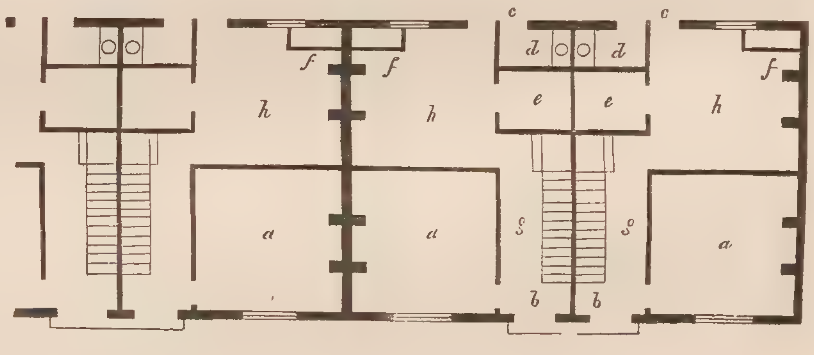
Fig. 10.



Chamber Floor of Two-Storeyed Cottage.

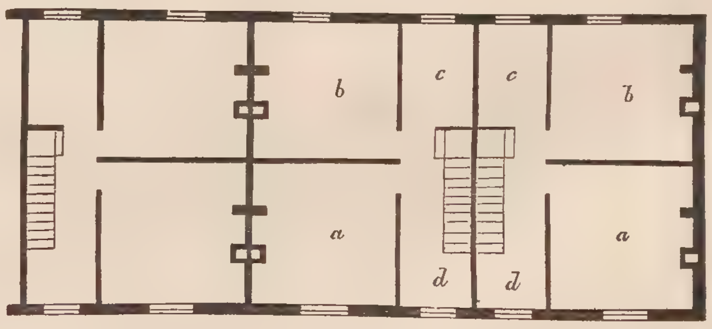
28. In fig. 11 we give the ground, and in fig. 12 the chamber-plan of cottages which may be built in a row of three, or, by doubling the plan, in a row of six. In fig. 11, *a* the living room, *b* the entrance, with the stairs on one side of the lobby, *h* scullery, with slop-stone *f*, and back door *c*, *e* store-closet entering from scullery *f*, *d* privy. In fig. 12 *a b* bed-rooms, *c* closet, *d* landing.

Fig. 11.



Half Ground Plan of Six Two-Storeyed Cottages.

Fig. 12.



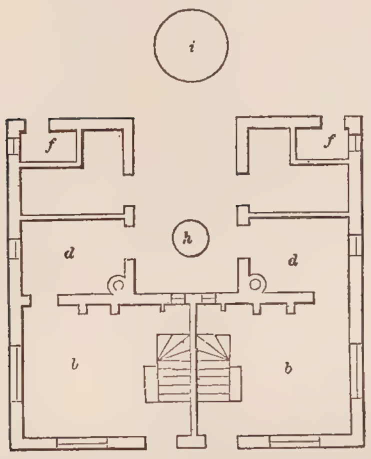
Half Chamber Floor Plan of Six Two-Storeyed Cottages.

29. *The Bedford Cottages.*—Few landed proprietors either in England or Scotland have done so much to establish good and comfortable cottages for the labourers on their estates as

the Duke of Bedford. Some of the cottages which he has built are looked upon by many as models of good arrangement. To enable our readers to judge for themselves and to draw some hints of value from them, we give a selection from the numerous illustrations given in the Journal of the Royal Agricultural Society, vol. x. part 1. Fig. 13 is the ground plan, and fig. 14 the chamber or upper floor of a pair of cottages.

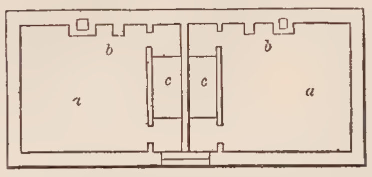
In fig. 13 *b* is the living room, 11 feet square, in which is a dresser; the wash-house, 10 feet by 6 feet, is at *d;* the coal and wood place adjoins, and is the same size as the wash-house, and from this is taken the privy at *f;* the well is at *h*, and the rain-water tank at *i.* In the chamber or upper floor plan the bed-room *a* is 11 feet square; it is supplied with a fireplace at *b; c* indicates the position of the well-hole or staircase. Fig. 15 is ground plan of a set of three cottages, having unequal accommodation, two of them having three, and the third only two bed-rooms. The kitchens, indicated by the letters *a a a*, are all the same size, 10 feet by 11 feet; the wash-houses, *b b b*, are 15 feet by 11 feet. In fig. 16, the chamber plan, the positions of the stairs are indicated by the letters *a a a; b c d* indicate the three bed-rooms of the two outer cottages; *e* and *f* the two bed-rooms of the inner or central cottage.

Fig. 13.



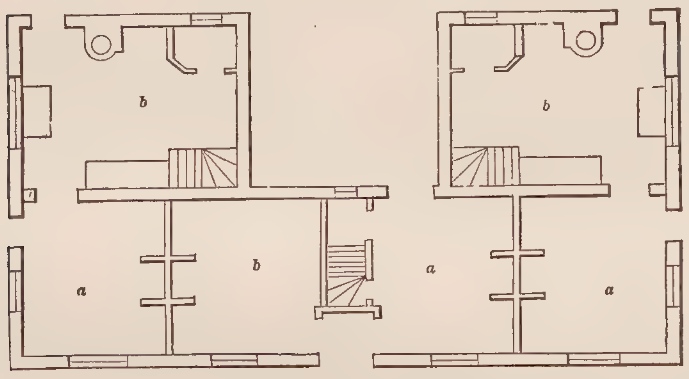
Ground Plan of a Pair of Cottages.

Fig. 14.



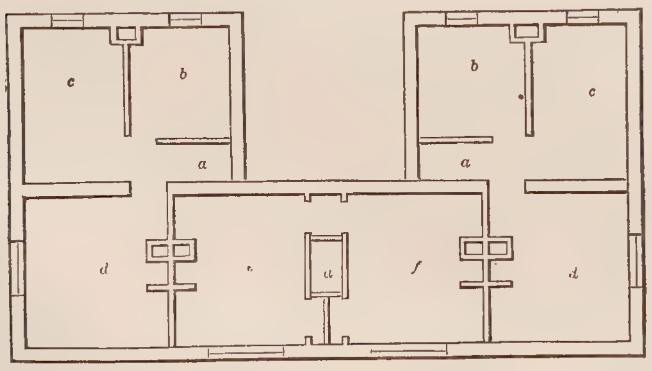
Chamber Plan of a Pair of Cottages.

Fig. 15



Ground Plan of Three Cottages.

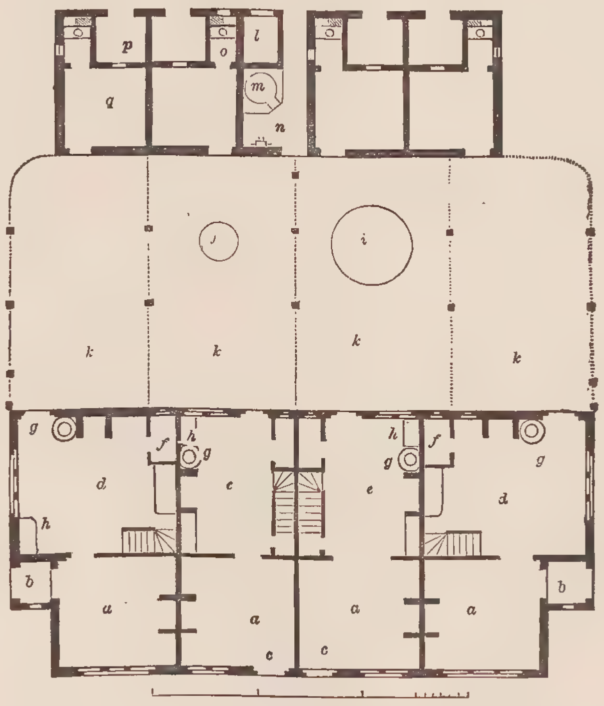
Fig. 16.



Chamber Plan of Three Cottages.

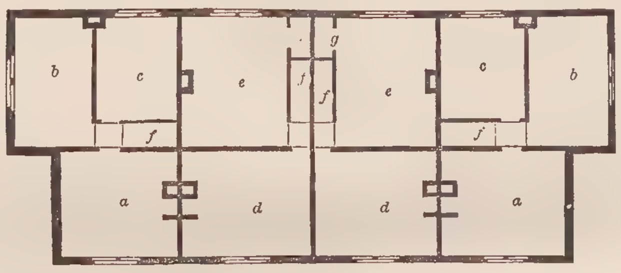
In fig. 17 we show a third arrangement, in which four cottages are placed together, two of which have three, and two of them two bed-rooms each. In fig. 17, the *ground plan*, are the kitchens, *a a a a*, 11 feet square; *b b* the porches of the two end, *c c* the doors of the two central cottages; *d d* the wash-houses of the end cottages, 15 feet 1 inch by 8 feet 6 inches; *f f* pantries, *g g g g* ovens, *h h h h* sinks, *i* rain-water tank, *j* well, *k k k k* yards for drying clothes. In the out buildings *l* is the ash place, *m* the oven, *n* the pump, *o* privy, *p* the pigstye, *q* the wood-house. In fig. 18, the chamber plan, *a a* are the front bed-rooms of the outer cottages, 11 feet square; *b b* back do., 12 feet by 7 feet 6 inches; *c c* do., 9 feet by 7 feet 6 inches; *d d* front bed-rooms of central houses, 11 feet square; *e e* back bed-rooms, 12 feet by 8 feet 6 inches; *f f f f* positions of stairs, *g g* closets. These plans were originally published in the Journal of the Royal Agricultural Society of England.

Fig. 17.



Ground Plan of Four Cottages.

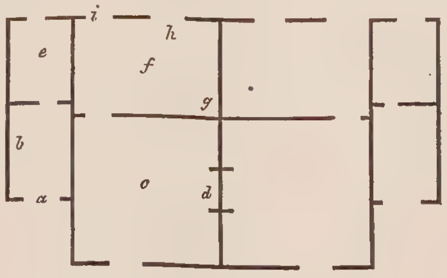
Fig. 18.



Chamber Plan of Four Cottages.

30. In a paper on 'Labourers' Homes' which appeared lately in the *Quarterly Review*, and which attracted considerable attention, a plan of Mr. Strickland's of Hildersley, near York, was specially eulogized. This plan Mr. Strickland, in a recent letter to the *Agricultural Gazette*, explains to have been designed merely to illustrate his remarks on plans which he was criticising, and then gives sketches of plans more fully bearing out his views as to what should be the arrangement of a pair of cottages. Of these plans as given in the number of the *Agricultural Gazette* alluded to we now give outline sketches. In fig. 19 we give ground plan, *a* the main entrance; the stairs are placed at the side, *b*, of the lobby or passage; *c* the living room or kitchen, 12 feet by 11; *d* position of fireplace; *e* pantry, 6 feet 9 inches by 5 feet; *f* scul-

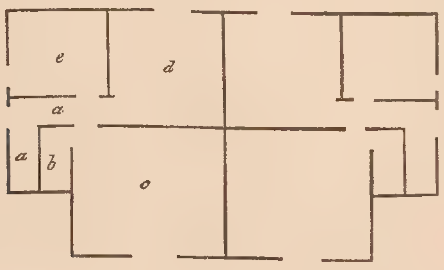
Fig. 19.



Ground Plan of Strickland's Cottage.

lery, 11 feet by 7 feet 6 inches; *j* shows position of "copper," or "boiler;" *h* that of the "sink" near window; *i* back door. In fig. 20 the chamber plan *a a* position of stairs; *b* closet, entering from front bed-room *c*; size of bed-room *c*, 11 feet by 10; *d* back bed-room, 9 feet 4 inches by 8 feet 4 inches; *e* side room, 7 feet 6 inches by 7 feet.

Fig. 20.

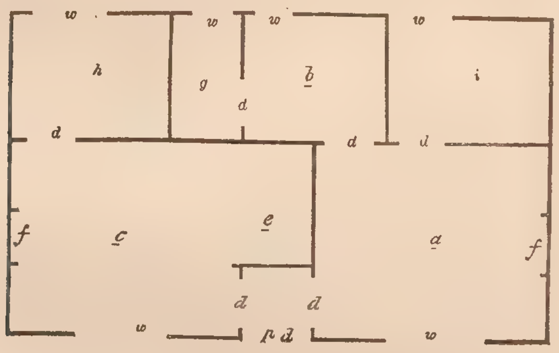


Chamber Plan of Strickland's Cottage.

31. The "Association for Promoting Improvement in the *Dwellings* and Domestic Condition of Agricultural Labourers in Scotland," has done great service by publishing and widely disseminating through the medium of their Annual Reports, a variety of designs for cottages of different sizes. Many of these have been erected in various parts of the country.

32. We give in figs. 21, 22, and 23, outline or skeleton sketches, which will enable our English readers to form a pretty fair idea of their arrangement of Scotch cottages. In fig. 21 we give the plan of a single storeyed detached cottage.

Fig. 21.

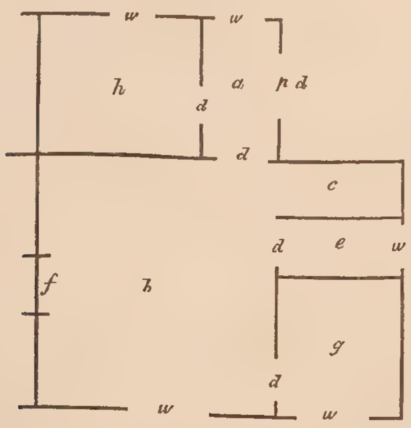


Plan of Single-Storeyed Detached Cottage.

(*Note* that in all the plans from figs. 21 to 29 inclusive the letters *p d* denote positions of principal entrance; *d d* internal doors; *f f* fire places; and *w w* windows). In fig. 21 *a* is the kitchen, 12 feet by 10 feet; *b* the scullery, 8 feet by 6 feet 6 inches; *c* the principal bed-room, 12 feet by 10 feet; *e* the space for bed; *g* pantry; *h* bed-closet; *i* ditto, each 8 feet by 6 feet 6 inches.

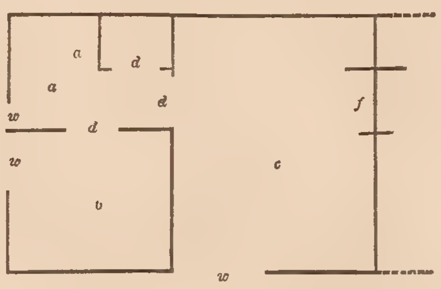
33. In fig. 22 we give ground plan of semi-detached two-storeyed cottages, in which *a* is the lobby, 3 feet 9 inches wide; *b* living room, or kitchen, 13 feet 9 inches by 11 feet; *c* position of stairs; *e* pantry; *g* bed-closet, 7 feet 6 inches by 6 feet 8 inches; *h* scullery, 8 feet by 6 feet 6 inches. In fig. 23 we give chamber plan, in which *a a* show position of stairs; *b* bed-room, 8 feet 6 inches by 7 feet 6 inches; *c* ditto, 13 feet 9 inches by 11 feet 5 inches.

Fig. 22.



Ground Plan of semi-detached Two-Storeyed Cottages.

Fig. 23.

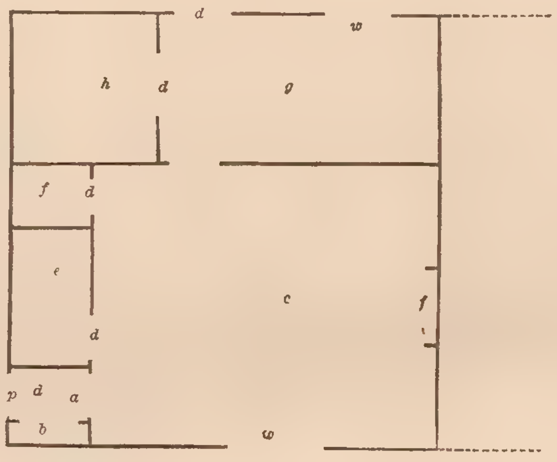


Chamber Plan of Cottage in Fig. 22.

34. In the summer of the present year (1861), the Yorkshire Agricultural Society offered a series of handsome prizes for the best designs for cottages and farm buildings; in competition for these no fewer than upwards of 300 designs were sent in. These were publicly exhibited in Leeds, and formed an exceedingly interesting and instructive display, showing an amazingly diversified set of plans. We attended this exhibition, and took many sketches, some of which we now present to our readers as exemplifying the *various forms or outlines* which cottages assume under special arrangements. These various forms were classified in the catalogue of the exhibition, the classification adopted being that of Mr. Strickland, already alluded to, who has a high reputation as an authority on cottage architecture. This classification, and some of the designs exemplifying it, we now proceed to give.

35. *Class m.* In this class the cottages have the advantage of "being within four walls," and the disadvantage of making passages of both the living rooms. Fig. 24 illustrates the ground plan of a cottage of this class, being the design exhibited by Mr. H. S. Snell of London; *a* is the porch, or lobby; *b* place for tools; *c* living room, 14 feet 6 inches by 12 feet; *e* position of stairs to second floor; *g* scullery, 12 feet by 6 feet; *h* pantry, 6 feet by 5 feet.

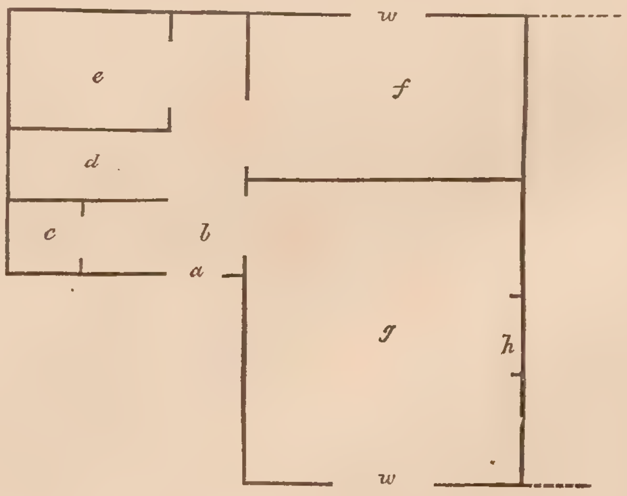
Fig. 24.



Plan illustrating Class *m* of Strickland's Classification of Cottages.

36. *Class m a.* Same as class *m*, but with staircase going out of scullery, and occupying place *h* in fig. 24

Fig. 25.

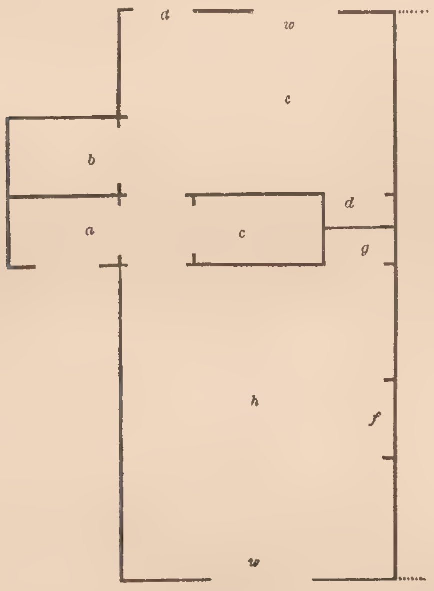


Plan illustrating Class *m b* of Strickland's Classification of Cottages.

37. *Class m b.* In this the entrance is at the side, thereby avoiding making a passage through the living room. "This," says Mr. Strickland, "is the best plan of a cottage within the four walls;" but he draws attention to the fact that there is generally a difficulty in arranging the chamber plan without cutting up the space by partitions. Fig. 25 illustrates the ground floor arrangement of a cottage of this class as designed by Messrs. Richardson & Ross, Darlington. This is the design to which the first prize was awarded. The entrance is at *a*, lobby at *b*, with closet *c* off it; *d* space for stairs; *e* pantry; *f* scullery, 11 feet 6 inches by 7 feet; *g* living room, 13 feet by 11 feet 6 inches; *h* position of fire-place.

38. *Class n.* In this the staircase is placed between the living room and scullery. "A very good construction for a cottage with two bed-rooms, but not for three." Fig. 26 illustrates class *n.* *a* lobby; *b* a pantry, 4 feet 6 inches by 4 feet 6 inches; *c* position of stairs; *d* space for oven; *e* scullery, 11 feet 6 inches by 7 feet 6 inches; *g* a closet off living room *h*, which latter is 13 feet by 11 feet 6 inches. This is a design by Messrs. Richardson & Ross, Darlington.

Fig. 26.

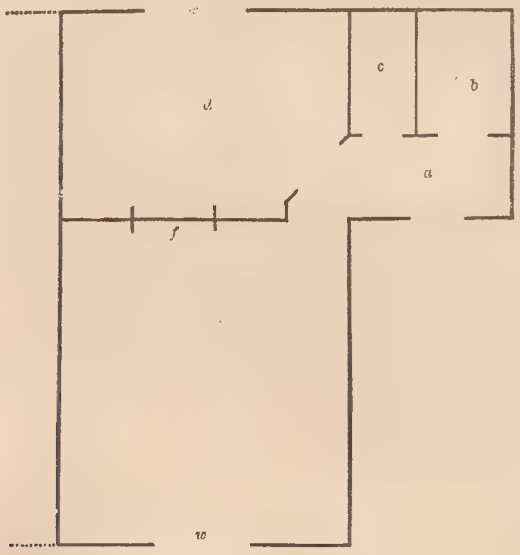


Plan illustrating Class *n.*

39. *Class o.* Cottages having the entrance in a recess in front, and the stairs in front of the part recessed, very similar in arrangement to fig. 25.

40. *Class o a.* In this class the staircase is in the back part of the cottage between the scullery and the pantry. Fig. 27. illustrates this arrangement, the design of Mr. J. Ferguson, Dalton, Newcastle-on-Tyne; *a* lobby; *b* pantry, 5 feet 3 inches by 3 feet 9 inches; *c* position of stairs; *d* scullery, 12 feet by 8 feet 8 inches; *e e* living room, or kitchen, 13 feet 6 inches by 12 feet, with window in centre of and opposite fire-place.

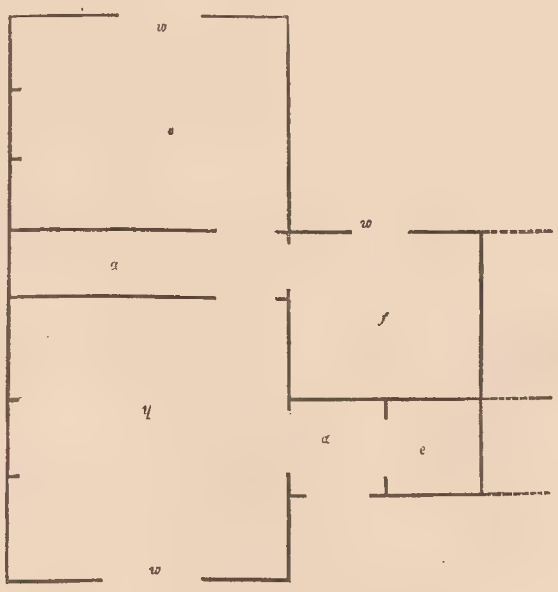
Fig 27.



Plan illustrating Class *o a.*

41. *Class o n.* In this class the cottages have a recess in front, and the stairs *a* between the living room *b* and scullery *c*, fig. 28. This is the design of Mr. J. Parkin, Idridgehay, Derby. In fig. 28 *d* is the lobby, 4 feet 4 inches by 3 feet 3 inches; *e* tool place, 3 feet 8 inches by 3 feet 3 inches; *f* the pantry, 8 feet by 7 feet; *b* living room, 12 feet square; *c* scullery, 12 feet by 9 feet.

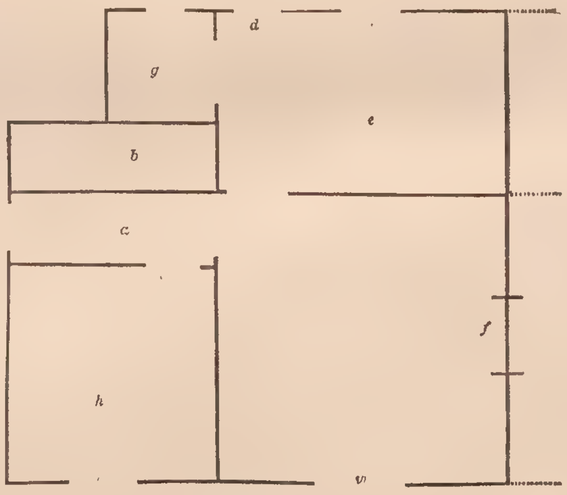
Fig 28.



Plan illustrating Class *o n.*

42. *Class p.* Cottages of this class have a "kitchen and parlour, or kitchen and one bed-room on the ground floor." This kind of cottage requires an entirely different plan of arrangement from that with the living room and kitchen on the ground floor and three bed-rooms above. Fig. 29 illustrates a plan of this class, which is the design of Mr. Cross of Harrow. Mr. Strickland characterizes this as one of the best sent in, and remarkable as being the only one of its kind having a living room and parlour with the door at the side. The lobby is at *a*; *b* the position of stairs; *c* living room; *e* scullery; *g* pantry; *h* bed-room.

Fig. 29.



Plan illustrating Class *p.*

43. *Class p a.* In this class of cottage the kitchen is at the back, the stairs facing the entrance. This arrangement is illustrated in the row of cottages in fig. 11.

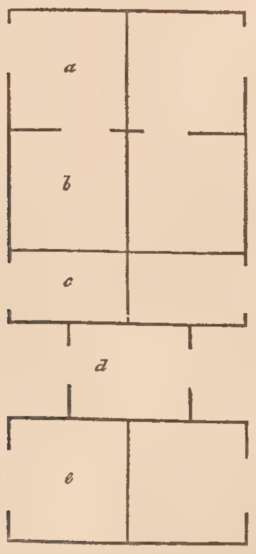
44. *Class p o.* This class is a modification of class *o n*, fig. 27.

45. All of the designs, from figs. 24 to 29 inclusive, are adapted to semi-detached cottages or pairs; we have, however, in the sketches, given half only of each design, the other half being but a repetition. We have not given the bed-room plans; the design which we have had in view in giving these sketches, namely, showing the various forms which cottages generally assume, being attained by giving part of the ground plan. As will be noticed, moreover, our sketches make no pretensions to completeness or great accuracy of drawing; but they are deemed, nevertheless, sufficiently full and de-

tailed to show the principle of arrangement adopted in each class.

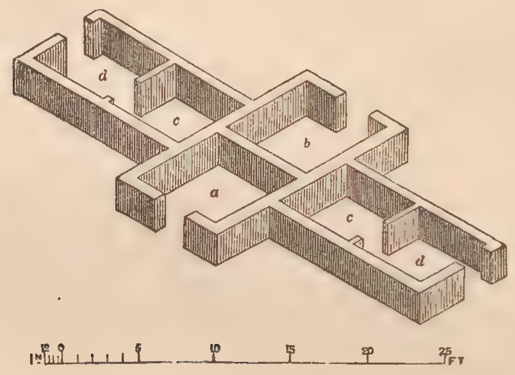
46. *Out-buildings.*—In figs. 30, 31, and 32, we give plans of out-buildings. In fig. 30, the arrangement is adapted for cottages in fig. 25, *a* yard, 4 feet 6 inches square; *b* pig-stye, ditto; *c* privy, 4 feet 6 inches by 3 feet; *d* ash-place, 4 feet by 5 feet; *e* coal-place, 5 feet by 4 feet. In figs. 31 and 32 we give designs of out-buildings for pair of cottages which we prepared for an article on cottage arrangement for the pages of the *Agricultural Gazette.* For these illustrations, as well as for those in figs. 33 to 36 inclusive, we are indebted to the obliging courtesy of the proprietors of that journal. In fig. 31, *a b* coal-houses; *c c* pig-sties; *d d* pig courts. This plan is designed for a composite cottage, as in figs. 35, 36, the privies or water-closets being in the lower house, as in fig. 35. In fig. 32 the out-buildings comprise privies; *a b* the two water-closets; *c d* the coal places; *e f* pig-sties.

Fig. 30.



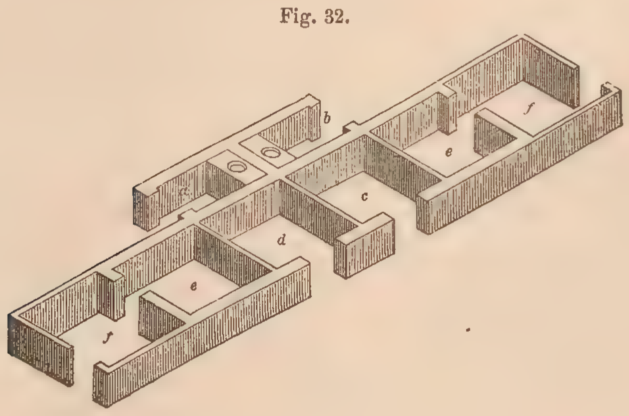
Plan of Out-buildings for Pair of Cottages.

Fig. 31.



Plan of Out-buildings for Pair of Cottages.

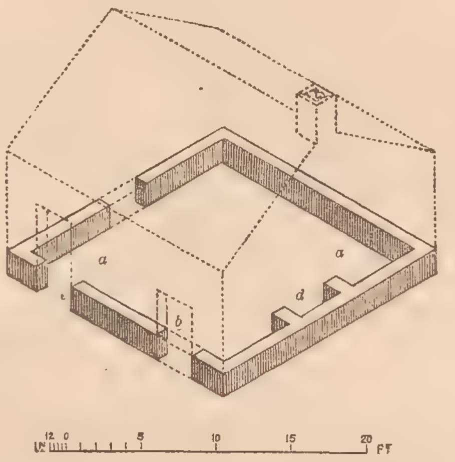
Fig. 32.



Plan of Out-buildings for Pair of Cottages.

47. *Improving Old and Defectively-arranged Cottages.*—Little space need be taken up in dilating on the importance of this department of cottage architecture. It has been suggested that by the change of old defective cottages into cottages containing good accommodation, more will be done quickly and effectively in introducing good cottage accommodation than even by the building of new ones. Be this as it may, it is evident enough that a vast number of wretchedly defective cottages exist which are capable, at a very small cost comparatively, of being altered and amended so as really to become comfortable and well-arranged structures. Take, for instance, the illustration in fig. 33 as a type of the kind of accommodation often—too often—met with in rural districts. "In this cottage we have but the one room in which the many inhabitants—the husband, the wife, the son, and the daughter—have to live, and in which all domestic operations have to be carried on, to the complete extinction of comfort, and, for the most part, the subversion of decency." It has a door *e* opening at once to the external atmosphere, giving free ingress to the biting blasts of winter; and windows, *b c*, generally of such miserably small dimensions as to preclude all chance of a good supply of healthy light being provided to the interior of the one room *a a*.

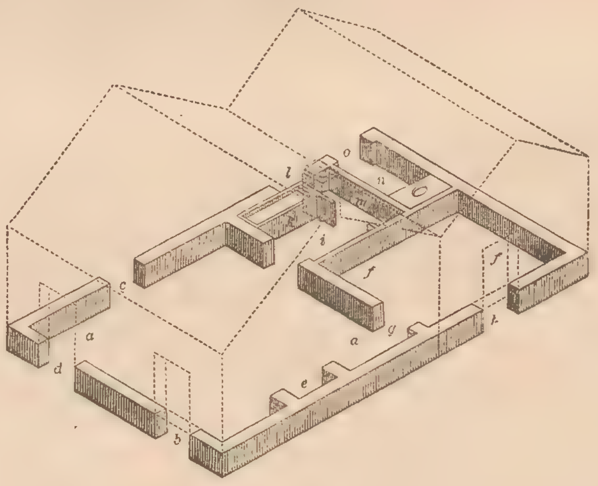
Fig. 33.



Plan illustrating a defectively-arranged Cottage.

48. It would be easy to "ring the changes," so to speak, upon this one-roomed cottage, and produce a variety of designs which would give comfortable accommodation; but having already given so many sketches of arrangement which will be useful as suggestions, we do not deem it necessary to give many "plans of amendment," but content ourselves with one only, as in fig. 34, which will serve to show how, by additions, the cottage in fig. 33 may be greatly improved. Thus, in fig. 34, *a a* the living room, corresponding in size, &c., to *a a* in fig. 33; *b c* windows; *d* door; *e* fire-place; *f f* back bedroom, with door *g* knocked through the old wall of cottage; *h* the window; *i* the scullery, with slop-stone *k*; window *l*; and with closet *m*; *n* water-closet; door *o*; or this water-closet *n* may be dispensed with, and made a linen closet, entering from bed-room *f f*, the door *o* being made up.

Fig. 34.

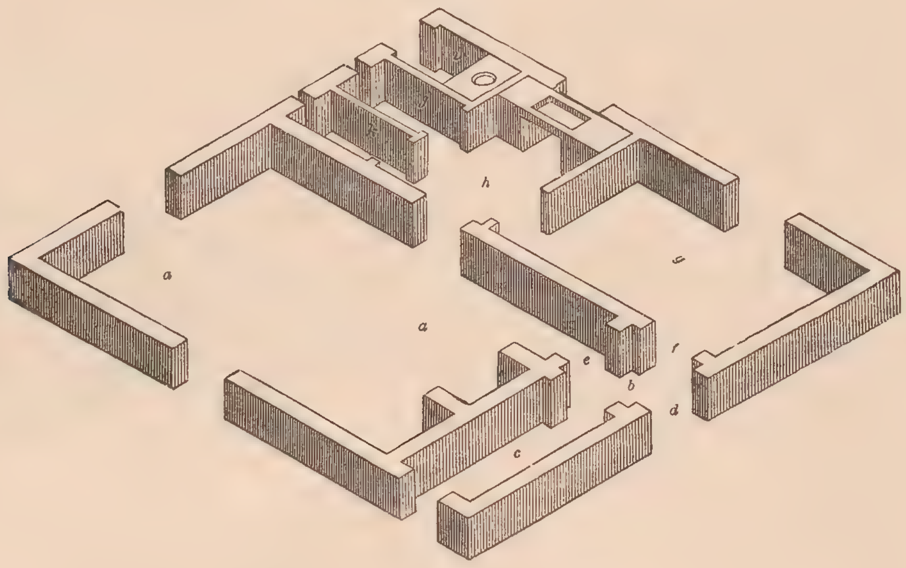


Plan illustrating Cottage in fig. 33 with additions and alterations.

49. "*Composite Cottages.*"—This term has been adopted to designate two-storied cottages, in which the lower storey forms a distinct cottage from the upper storey—both cottages having independent entrances. Generally speaking, the upper cottage is gained by a stair at the back, although, in some cases,

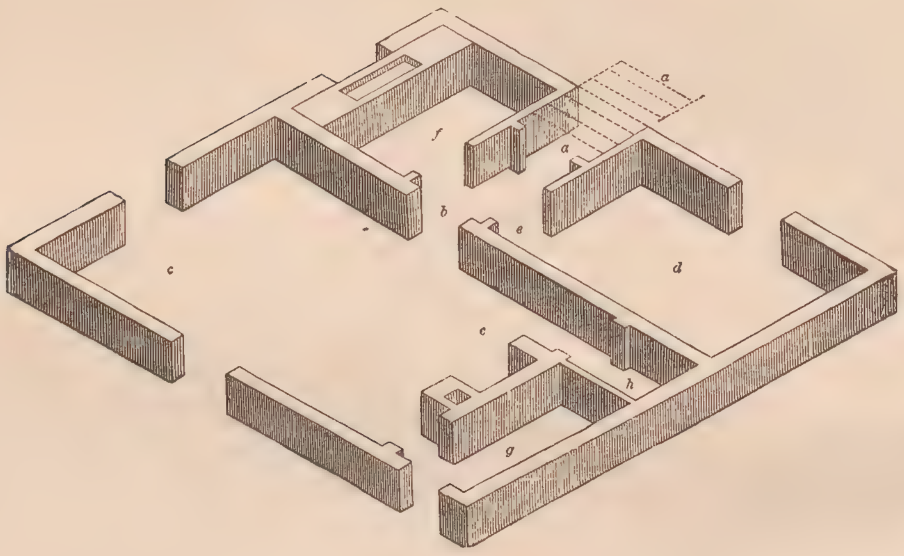
the stair is entered from the front. Fig. 35 is the ground plan, or lower cottage; fig. 36 the upper plan, or upper cottage of a composite cottage. In fig. 35 *a a* is the living room; *d* the side door; *c* a store-closet; *g* a bed-room, entered by door *f*; *h* scullery; *i* water-closet; *j* store-closet; *k* coal store. In fig. 36 *a a* stairs, partly outside the building and partly in the interior; *b* door to living room *c c*; *d* bed-room, door *e*; *f* scullery; *g* closet; *h* ditto.

Fig. 35.



Ground Plan, or lower storey of a Composite Cottage.

Fig. 36.



Ground Plan of "Composite Cottage."

50. We have yet to refer to the class of houses adapted for working men who live in streets. These may be classed under two heads—houses or cottages built on, first, the *independent, or self-contained plan* (this being the arrangement adopted in England); and second, the *flat system* (this being the arrangement generally adopted in Scotland.)

51. The English, or "self-contained" plan, is illustrated in Plates IX. and X., and the houses of which — two-storied—may be extended to any length. The chamber plans of the houses in Plate IX. are arranged identically, as the *Kitchen*, *Sitting-room*, and *Parlour*, the only difference in the arrangement of the chamber floor being that the space of the lobby in the ground floor is added to the *front bed-room*, which is above the parlour in the ground plan. The sitting-room is cellared under. The arrangement of the two plans being so identical in outline, it has been considered unnecessary for the purposes of our Essay to take up space with a plan of the chamber floor and cellar plan of the row of street houses illustrated in Plate IX. The same remarks apply to the plans in Plate X., figs. 1 and 2, which illustrate a row of houses adapted for manufacturing districts. These two plates will serve to illustrate the style and class of street houses on what we designate the English, or "self-contained" style. A further illustration of this style—modified, however—is met with in the "Composite Houses," described and illustrated in a former paragraph of this Essay (No. 49). In this style each house is "self-contained," but yet somewhat on the flat principle, which we are now about to describe.

52. The best exponent of the peculiarities of the "Scotch," or "flat" dwelling-house system, is Mr. William Chambers. In his pamphlet, "Improved Dwelling-houses for the Humbler and other Classes in Cities," the whole bearings of the matter are fully and ably put. Referring to the "independent," or "self-contained" system of English houses, Mr. Chambers attributes its origin to the peculiarities of national character. Every Englishman is supposed to have such a love of independence that his house he must have entirely to himself, making it, as the phrase goes, his "castle." He has complete control over every department, external and internal; he rules over the tiny plot in front and the too-confined yard at the back; he controls the entrance-door, and has a command over the hall lobby and stair. But pleasing as this contemplation of independence is, the means by which it is secured are, Mr. Chambers submits, not so economical as might be desired. It is a question, he thinks, whether this separate perpendicular form has not been carried too far. So far as the superior houses built on this principle are concerned it matters little; but in cases of inferior houses all the disadvantages of the system are apparent on examination. They do not afford the accommodation proportionate to the extent of land they occupy. They are not economical in construction; a stair and a roof are required for one house, while on the "flat" system the expenses of these adjuncts are spread over several houses. The division walls are thin and insecure, and the predominance of wood in the construction of the houses renders them

liable to sudden and destructive conflagrations. Mr. Chambers further points out that much of the independent "each-man's-house-is-his-castle" feeling, is done away with in houses on the English system, built in inferior districts and for an inferior class of tenants, from the habit which obtains amongst them of crowding many families under one roof. This objection, however great, is not one which belongs exclusively to the system, for it is obviously as likely to be the case—and, indeed, is the case—where the houses are built on the "flat" system. There is as much overcrowding of families in a "flat" in the High Street of Edinburgh as in the houses of the "far-stretching masses of small and dingy tenements seen from the Blackwall, the South Eastern, and the South Western Railways," to which Mr. Chambers specially refers while noticing this objection.

53. The "flat" system is in this kingdom peculiarly Scotch. It obtains in Paris in a marked degree also, but with modifications, to which we shall specially refer. In the flat system the separate houses are piled one above another, access being had to all of them by a stair common to the whole structure, and hence called a "common stair"—common, we may here be allowed to interpolate, in more ways than one, as one or two of the senses can testify when a "common stair" is entered. Generally speaking, the "common stair" gives access to two houses on each flat—the doors entering right and left of the landing, as will be seen on reference to figs. 3 and 4, Plate X.

54. The whole accommodation, then, of a house on the "flat," or Scotch system, is on one level; while in the "independent," or English system, the accommodation of the bedrooms is on a floor above. To get the whole range of apartments required in a house on one level necessitates an increase of either breadth or depth of building. In Scotland the increase of superficies is obtained by giving a greater depth to the building than is generally the case in English houses. The whole details of construction are on a stronger and more permanent basis than are met with in England. The common stair is invariably of stone; the party walls are very thick, as well as the exterior ones. "Deafening," or mortar, is almost always used between the floor of one house and the ceiling of that immediately below it, and the partitions internally are almost always of brick. The result of all these structural arrangements is that Scotch houses are rarely totally consumed as in England; and from the comparative slowness with which the fire takes hold of the solid materials, time is given to the inhabitants to escape, so that lives are rarely lost.

55. There are many points still to be referred to in connection with the "flat system," but as these have reference to houses of a superior class we shall discuss them in the Second Division of our paper, meanwhile giving here a brief description of houses for the working classes on the flat system, as built in Edinburgh, and referred to by Mr. Chambers. The building is of three stories, having accommodation for two families on each story. A passage from the outer, or street entrance, extends through the building from front to back. At the back end of this passage the stairs begin to ascend. Each house consists of a kitchen 12 ft. 9 in. by 10 ft. 6 in.; a bed-closet entering from this, 6 ft. 6 in. by 5 ft. 9 in.; a coal-place entering also from kitchen; a sitting-room, 12 ft. 9 in. by 11 ft. 5 in.; a bed-room entering from lobby, 8 ft. 9 in. by 7 ft.; a water-closet enters from the lobby, and is lighted from the stair. A small "green" at the back is common to all the families, and is used for drying clothes.

56. In concluding Division First of our subject, which, in accordance with the arrangement in par. 5, takes up the subject of "Cottages for Working Men," it will be advisable to give the opinions of various authorities on the important points of—first, *site and position of the buildings;* second, *size of the rooms;* and third, *general conveniences, as supply of water, water-closets, or privies, &c.* On these points we purpose giving more the opinions of others than our own; in this way the reader will be presented with a variety of statements, each stamped with the individuality of the authority who gives it, and valuable as embodying his experience; so that on perusing them, along with what we have already presented him of our own, the reader may consider himself well "posted up"—to use a familiar expression—in all matters connected with the question of "Working Men's Cottages."

57. The question of *site* of the cottage, so far as houses in towns are concerned, is very much narrowed by obvious considerations; but for cottages in the country a wider latitude of choice is given, so that it is of importance to know the reasons upon which that choice is founded. The first authority we shall quote is that of the author of the prize essay on "Cottages," given in the Royal Agricultural Society's Journal, Vol. X, Part I., p. 231.

58. "Such a variety of circumstances, both natural and local, have to be considered in determining upon sites for the erection of labourers' cottages, that the adoption of any fixed rules seems almost impracticable. It may not be amiss, however, to suggest that a plot of land, abutting upon and at a level of from two to three feet above a good road, forming part, or being in the immediate vicinity of an allotment of land available for spade husbandry, and possessing facilities for efficient drainage, seems most desirable; and in all cases care should be taken that the habitation of the labourer is not too remote from the locality of his daily avocations. The aspect should be south, or as nearly so as can be obtained, and the value of the situation would be enhanced if protected on the north and east from the inclemency of the weather; but the close proximity of forest trees should be avoided, as having a tendency to deteriorate the value of the garden ground, and in the autumn to clog up the gutters and spouts of the cottages with dead leaves. A good soil, of easy cultivation, with a substratum of gravel or sand, is essential, or (when prevailing prejudices are overcome), a piece of used-up old grass land, sufficiently elevated for draining purposes, would not be unsuitable."

59. In the "Annual Report (First) of the Directors of the Association for Promoting Improvement in the Dwellings and Domestic Condition of Agricultural Labourers in Scotland," the following is given on the question of site:—

60. "The choice of a site is a point of the greatest importance, as on it depends in some measure at least whether the house shall be dry and healthy or damp and unhealthy. It should be capable of being effectually drained, and should also, if possible, be near a good supply of water. The cottage should be so placed that the sun may shine on it all round, especially on those parts which are used as sleeping apartments."

61. Dr. Watson, in the pamphlet already alluded to, par. 7, says on this point of site:—"The salubrity of a dwelling-house depends upon its site, a proper supply of water, shelter, and warmth, without dampness.

62. "The situation to be selected for the houses or cottages of agricultural labourers should be such that, if possible, the front should be to the south, the ground should be dry, and somewhat elevated above adjoining fields, so as to admit of the drainage, near to a supply of water, and have some shelter from cold and violent winds, more especially on the north and east, by high ground or trees; each cottage should have a piece of ground attached to it in front.

63. "By placing the garden in this position, when the house fronts the south, it is more sheltered, and is not shaded from the sun, and consequently is earlier and more productive than otherwise, and by being constantly in view, greater attention

will be paid to its cultivation. If placed in front of the house, between it and a high road, the occupants of the house are also thus removed from noise and dust, which render a house close to the roadside uncomfortable.

64. " Such houses generally require to be surrounded by a well-made drain, laid with tile pipes and broken stones, for the double purpose of carrying off all dampness from the ground, as well as rain and foul water from the house.

65. " The locality selected should possess a supply of pure water, which should be introduced into the house by means of a pipe, and soil-pipes should be laid from the kitchen and bed-rooms so as to carry foul water into the drains. Near to the windows is the best situation for such soil-pipes, which may be fitted with a wash-hand basin, or a small trough of cast-iron or porcelain.

66. " The situation selected for the house or houses (if more than one is to be built), should have sufficient space to render them free and open all round, but particularly in front and back, in order to secure the circulation of fresh air without dampness or moisture. There should be no trees close to the house."

67. " On the *position*, or aspect of the cottage, Mr. Stephenson, in his " Cottage Homes of England," has the following:—" Where the owner of the property is not particular to a few yards of land, he should not insist upon the cottage being built parallel with the road, or uniform, as it is termed, with others already built, or in a line with them, especially when such existing buildings are not placed north-west, south-west, north-east, or south-east, for it is of the utmost importance so to place them in order to get the sun all round the building. These aspects apply to all buildings for human habitations, and should always be borne in mind by the intelligent workman, builder, and owner of property.

68. "The cottage should be placed midway its width of land, so as to admit the action of the sun's rays all round, as well as to allow access to the garden and back premises. The front portion of land should be laid out as an ornamental flower and herb garden, with small grass plot (to taste). This garden of the full length of the house frontage, and not exceeding twelve yards, or less than eight yards in width; but this arrangement must in many instances be guided by circumstances."

69. The following, on the same point of position, is given by a writer in the " Builder's Practical Director:"—"Two important requisites of an agricultural labourer's cottage are, that it should not be far from the scene of his daily avocation, and be surrounded by a garden, one-sixth of an acre being usually considered the minimum space. The most convenient situation, and that generally selected from its convenience of access, is a few yards from a public road. A small portion of the ground attached should always be in front, as well for the advantage of certain desirable privacy as that it may be appropriated to the cultivation of a few herbs and flowers, better separated from the kitchen or produce part of the land. The cottage should not be placed parallel to the road, but at an angle, that a view may be obtained, not only in front, but *down* the road. The aspect will, doubtless, be nearly always contingent on circumstances. Where, however, the power of choice exists, that towards the south-east, from which, in this country, the wind blows seldomer than from any other quarter, should be preferred. The next best is the south, and if the bed-rooms front the east, there is the advantage that the first rays of the sun may remind the industrious labourer of the duties of the day. If possible, the cottage should be protected from the north by trees, but these have their disadvantage in deteriorating from the value of the ground. That position is the best which enables the sun to shine on all sides of the dwelling, and this may always be obtained by placing the square of the plan diagonally with the cardinal points, so that the north and south line passes through the angles, the principal front being towards the south-east."

70. The question as to the best *size of the rooms in cottages* is, as may readily be supposed, an undecided one. We can only here give a few of the dimensions as adopted by various authorities. The size of the *living room*, according to one, should be not less that 12 ft. square; according to another, 13 ft. by 12 ft.; a third gives 15 ft. by 11 ft. as the size; a fourth authority, 11 ft. by 13 ft.; a fifth, 13 ft. by 12 ft. 6 in.; a sixth, 11 ft. square; a seventh, 10 ft. by 11 ft.; an eighth, 16 ft. 6 in. by 12 ft.; a ninth, 23 ft. 6 in. by 17 ft.; a tenth, 13 ft. by 11 ft. 4 in.; an eleventh, 12 ft. by 11 ft.; a twelfth, 13 ft. by 11 ft.; a thirteenth, 13 ft. by 12 ft.; a fourteenth, 16 ft. 3 in. by 11 ft.; while a fifteenth authority says that a living room should never have a less area than 120 ft., which will be given by a size of 12 ft. by 10 ft. On this point we may add the result of our own experience, which is, that the best size of living room, which is neither too big nor too little, and the proportions of which will always please, is 14 ft. by 12 ft.

71. As to the size of the *scullery*, or *washhouse*, the same diversity of opinion exists. One authority gives it as 8 ft. by 6 ft.; a second gives it at 8 ft. by 12 ft.; a third, 14 ft. 9 in. by 7 ft. 3 in.; a fourth, 8 ft. by 6 ft.; a fifth, 6 ft. 6 in. by 5 ft.; a sixth, 8 ft. by 6 ft. 6 in.; a seventh, 14 ft. by 6 ft.; an eighth, 12 ft. 7½ in. by 7 ft.; a ninth, 12 ft. by 8 ft. 6 in.; a tenth, 10 ft. by 6 ft.; an eleventh, 7 ft. by 8 ft. 6 in. We incline to look upon 8 ft. by 6 ft. as a very convenient size for a scullery of a cottage.

72. As to the *size of the bed-rooms*, one authority states that no bed-room should have a less cubical content than 500 cubic feet—the prison allowance being this—for each individual, and gives for a small room dimension 8 ft. by 8 ft., and 8 ft. in height; for large room, 12 ft. by 12 ft., and 8 ft. in height. Another authority states that no bed-room should have a less area than 43 square ft. The following is a list of dimensions taken from various examples—12 ft. by 12 ft.; 11 ft. 6 in. by 9 ft.; 10 ft. by 9 ft. 4 in.; 9 ft. by 7 ft. 6 in.; 12 ft. by 8 ft. 1 in.; 13 ft. by 11 ft. 4 in.; 10 ft. 6 in. square; 16 ft. 6 in. by 12 ft.; 11 ft. square; 11 ft. by 7 ft. 6 in.

73. In cottages of two stories, we may remark, the size of the bed-rooms on second floor, as a rule, will be dictated by the size of the rooms on the ground floor, the walls running from floor to roof. The full size given, this should not be cut up by partitions in order to get more sleeping apartments; but it will in every way be better to give the same size to the bed-rooms as to the rooms below. We are no advocates for cutting up large into small spaces; let the bed-rooms of a cottage be the largest in the house. Remember that a working-man spends the most of the time he is at home in his bed-room, so that there is every inducement to make it the healthiest room in the house.

74. The *height of the rooms of cottages* is usually given at 8 feet. This we think too low. We should recommend a height of 10 feet for the ground-floor rooms; and if economy is considered before health, 9 feet for the bed-rooms; where health is thought of, let the height of the bed-rooms be as great, or greater, than that of the ground-floor rooms.

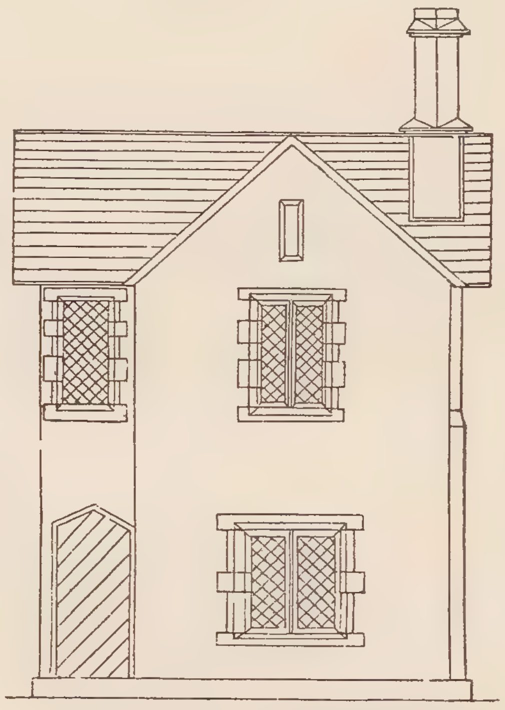
75. We now come to the consideration of the general conveniences, as supply of water and privies. And first, as to the *supply of water*, on which, however, little surely need be said. It is apparent, on the very narrowest view of the subject, that a supply of water is essential both to the health and comfort of the inhabitants, and to enable them to promote personal and household cleanliness. We have heard much said of the lack of cleanliness in both of these respects evi-

denced by the working classes. True, it does obtain amongst them too markedly, but in extenuation it should be borne in mind that in many cases, especially in cities, no water is supplied to the houses, but a precarious supply is only obtainable by going to public wells or pumps for it. And let any one say who knows what hard work really is, whether, after a whole day of it, there is much spirit left to enable one to add to it so grievously, as by going out to some distance for a supply of water. The chances are that the personal or household "cleaning" which was contemplated is put off, just as we put off many duties, till a more convenient opportunity. Moreover, it does not follow of necessity that when the labouring man goes or sends for a supply of water to the public place that the supply is to be obtained. Frequently the water —if dependent on a public company—is cut off, and the errand is bootless. This element of uncertainty also acts as a reason why excuses should be frequently made by working people for not having a supply of water in their houses. Still further, when the supply is brought to the house, little convenience is there met with, for storing it up. All these remarks apply with equal, if not greater, force to country cottages. Too often these are placed with a total indifference to the supply of water in their immediate neighbourhood. Such a thing might never be required so far as any evidence of its necessity is shown by the builders of cottages in rural districts. The moral of all this is that it is essential to have the supply of water taken direct to the interior of all cottages, whether in town or country. In the latter, where the lack of "pressure" prevents this being done, it will be imperative to have the well or pump as near the house as possible. Before want of personal or household cleanliness is laid as a high fault to the door of working people, let it be seen that they have the means of securing both, and that without the expenditure of a degree of labour, which we have no right to ask from them. Pious followers of Mahomet, in travelling through desert places where no water is, believing in the necessity there is for performing their daily ablutions, still go through the empty form at the stated times. But truly *we* are not Musselmans to wash with "invisible soap and make-believe water."

76. Let us now very briefly turn to the subject of *privies*, or *water-closets*. How the necessities of physical organization are met, under circumstances where such conveniences are *not* given to "the huts where poor men lie," or in the houses of crowded streets of populous cities, passes our comprehension. Such a condition of matters must of necessity bring about a high degree of moral as well as physical degradation. All houses—and we admit of no exception to this rule—should have a privy, or water-closet, as an essential part of the house arrangement. In country cottages it is a disputed point whether this should be placed in the interior of the house or in the yard or garden. Much will depend upon locality in deciding this. We ourselves are in favour of the exterior arrangement. The space taken up by it in the interior of a cottage can better be employed, while all smells, &c., can be avoided. In street houses on the "flat" system there is a necessity for having the closet in the house; but in the great majority of cases in manufacturing districts of England the street houses have yards in which the privy is placed. For the arrangement adopted as a rule see the plan in Plate IX.

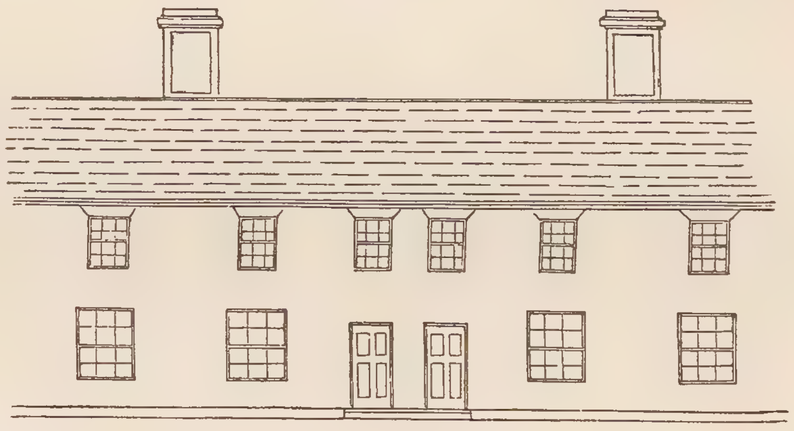
77. Before proceeding to the next division of our paper, it will be well here to make a few remarks on the style of elevation of cottages. This should be plain and simple, although in some cases, especially in rural districts where ornament is sometimes desiderated, a little attempt at decorative style may be permitted. Fig. 36 is a suggestive design for the front elevation of a house, of which the plans are given in figs. 9 and 10, p. 7, and fig. 37 that of the row of houses in figs. 11 and 12. In Plates IX. and X. elevations of street houses are given, and in Plate VII. also a series of suggestive designs for front elevation of cottages, the plans of which have been already illustrated in preceding pages of this Essay. Fig. 1, Plate VII., is the front elevation adapted to cottage in fig. 2, p. 5. Fig. 2, Plate VII., is the elevation adapted to fig. 2, p. 5. Fig. 3, Plate VII., that adapted to fig. 5, p. 6. Fig. 4, Plate VII., that adapted to fig. 5, p. 6, detached. Fig. 5, Plate VII., that for fig. 4, p. 6. Fig. 6, Plate VII., that for fig. 13-14, p. 8.

Fig. 36.



Front Elevation of Cottage in Figs. 9-10.

Fig. 37.



Front Elevation of Row of Cottages in Figs. 11-12.

Division Second.—Dwelling Houses, Rural and Suburban Villas, and Farm Houses.

78. In the opening paragraph of the present Essay we ventured to offer a few remarks on the important subject of planning, and took occasion to animadvert pretty strongly on what we think the wrong way in which "planning" a house is gone about. Although these remarks were made as specially introductory of the arranging of cottages for the working classes, still they have a pretty direct reference to the subject of villas and houses of a superior description. Houses are certainly made to live in, and that being their primary use, it is of essential importance that the arranging of the house so as to insure comfort and health in living in it, be attended to. But in houses of a superior class there is another, and although it is but a secondary, still it is an important consideration, namely, the house must have in its exterior decoration that which pleases the eye of the owner. Much as we desiderate utility in the arrangement of the house of a man of means, we do not lose sight of the importance of securing beauty in its design. "A thing of beauty," says

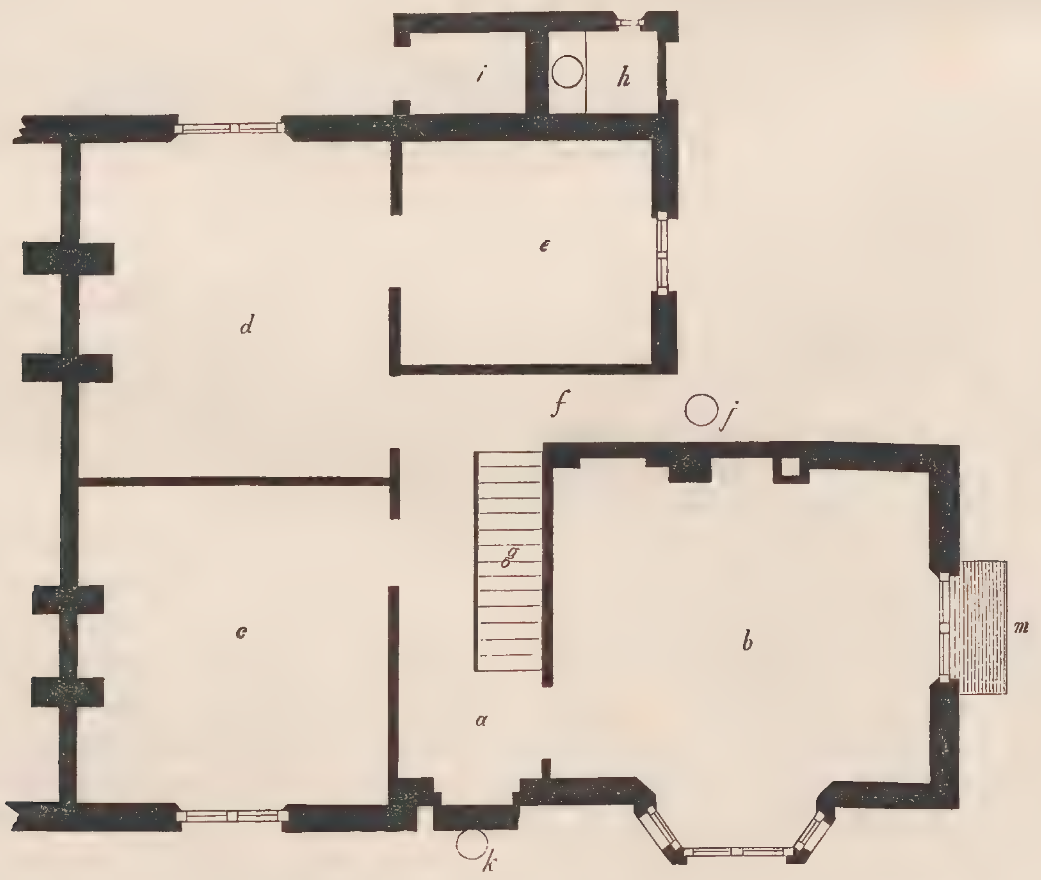
Keats, "is a joy for ever," and suggestive enough is this same sentence of the poet's. We see this union of the useful and the beautiful everywhere around us; we have the corn and the coals, but no less the flowers and their fragrance; and God, sending those delights of the eye which make this world such a place of beauty, means us no doubt to lovingly and faithfully appreciate them. It is no mean thing, therefore, to inculcate on all around us, and within our influence, a love of the beautiful, whether in form or colour. And so far as beautiful in form of a house is concerned, it may almost be put down as axiomatic that it can be secured at a very little extra outlay compared with that necessary to obtain a house, the form of which is anything but pleasing or attractive. It is a somewhat singular thing, as remarked by a trenchant writer on architecture, that numerous as publications are on the subject of architecture generally, not a single one gives instructive studies of plan; and he continues to remark, that "instead of more, less attention than ever seems to be now given to planning. To judge from specimens of it in some recently-erected mansions, plan is now reduced to what is no better than mere 'box making,' and something like tolerable knack in putting together so many rooms, but without any attempt at artistic effect, either as regards the separate rooms or their arrangement and combination. In fact, as far as planning is concerned, there appears to be now little or no occasion for an architect. The number and size of the rooms being given, a bricklayer can lay out a house just as well as many who write 'architect' after their names, yet who, instead of laying out a house, just tack together so many four-sided rooms. If the dining-room be put just by the hall door, and further apart from the kitchen than any of the other rooms, that seems, according to some recent examples, to be considered the '*ne plus ultra* of contrivance and ingenuity.' Much, if not all, of this is peculiarly suggestive; the plan, as well as the exterior decoration or style of a house, should always give evidence of mind having been bestowed on them. Nothing offends the man of taste so much, as finding in a succession of houses which he inspects or visits, a weary repetition of arrangements of rooms and of exterior decorations, as if the whole of them had been designed to order, and cast or moulded from one original. We appeal with confidence to the reader if he is not always charmed with evidences of mind in contriving and arranging the plan of a house, and doubly so where 'surprises' are met with in matters of arrangement, of which the exterior of the house gives no sign." The writer whom we have just quoted says on this point—"Anything but disappointing it surely is, to find, on going over a building, that it contains much which —no promise of it being made by the exterior—takes quite by surprise. Without pretending to dictate to others what they ought to like or dislike, I confess that I am greatly delighted with surprises of the kind, and with effects which, after they have ceased to be 'surprises,' continue to be captivatingly charming."

79. In the opening paragraph of this Essay we have alluded to the method of first deciding upon what is wanted in a house, working out the plan thus, and allowing the plan to dictate what the elevation should be. The plan, then, should be that to which the attention of the party intending to build should be directed. The architect or builder need not at first trouble his client with elaborate elevations or intricate sections and details. As a rule, clients are ignorant of these, but a plan he can understand; and if drawn isometrically, as in figs. 33, 34, and 35, this understanding on his part will be all the more easy.

80. We now present a few plans of dwelling-houses which may be suggestive of arrangement.

81. In fig. 38 we give the ground plan of a semi-detached suburban villa, in which *a* is the lobby, *b* the drawing-room, *c* the dining-room, *d* the kitchen, *e* the scullery, *f* back passage, *h* servants' water-closet, *i* tool house. Fig. 39 is the bed-room plan, in which *a* is the landing; *b* principal bedroom; *c* and *f* bed-rooms; *e* servants' bed-room; *d* water-closet; *g* rain water cistern above servants' water-closet *h* and tool house *i* in fig. 38. Fig. 40 is the cellar plan, in which *a* is the principal room for storing provisions, reached by the stair *b*, which enters from the back passage *f* in fig. 38; *c* is the boiler; *d* drying closet; *e* window, lighted by grating *m* in fig. 38; *f* beer barrel, or wine bin place; coals, potatoes, &c., are passed down the shoots *g* and *h*, the apertures of these being secured by gratings placed at *k* and *j* in fig. 38. Fig. 41 is the half front elevation. The scale to which the drawings are made is one-eighth of an inch to the foot.

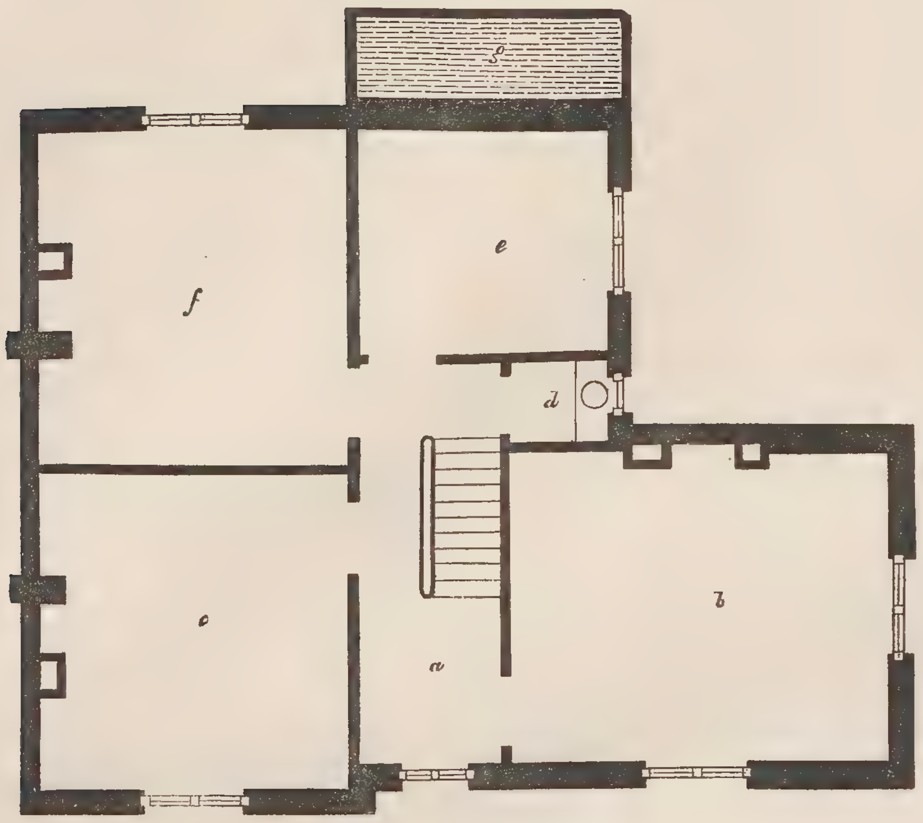
Fig. 38.



Ground Plan of Semi-detached Suburban Villa. Scale, ⅛th inch = 1 foot.

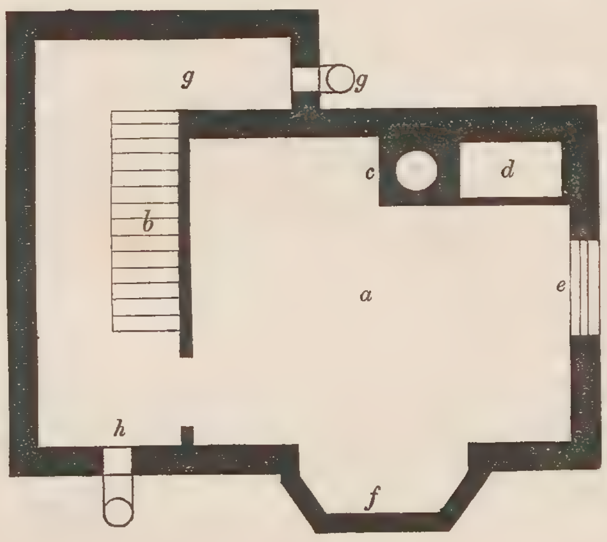
82. Fig. 42 is the ground plan of a detached villa, in which

Fig. 39.



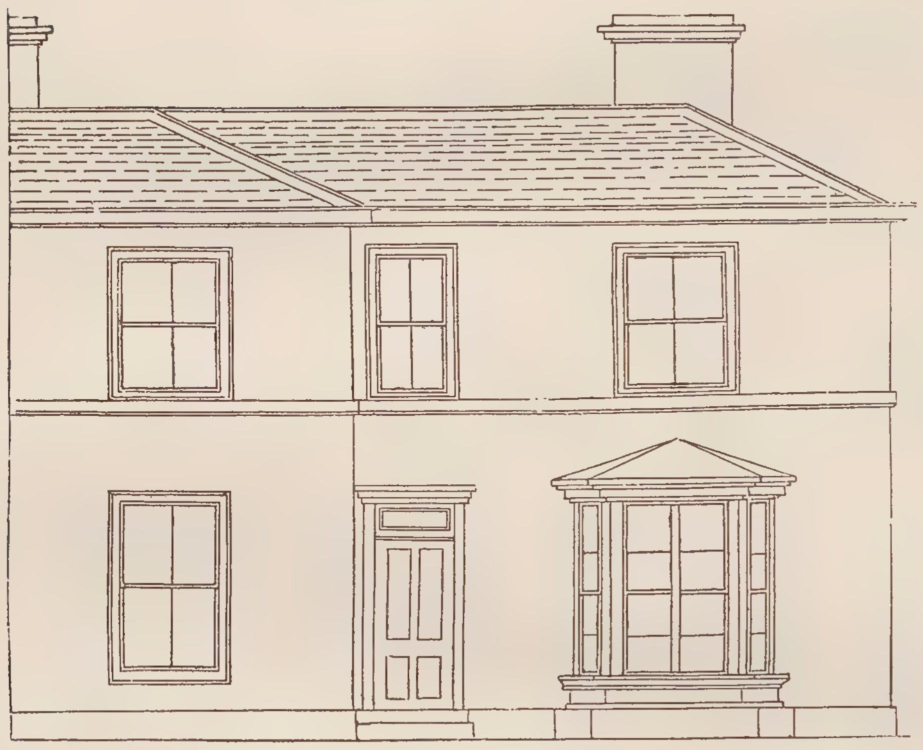
Bed-room Plan of Fig 38.

Fig. 40.



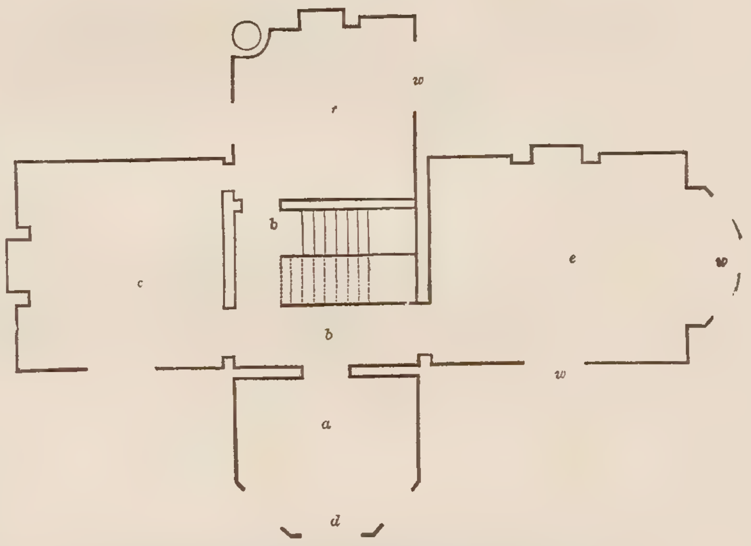
Cellar Plan of Villa in Fig. 38.

Fig. 41.



Half Front Elevation of Villa in Fig. 38.

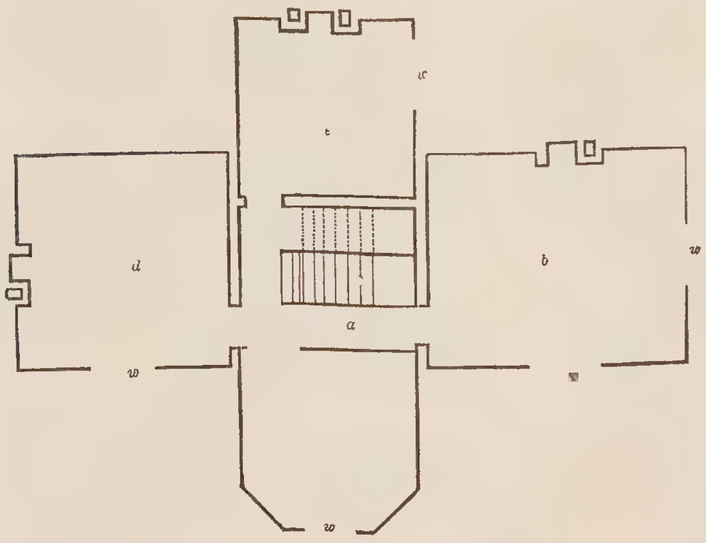
Fig 42.



Skeleton Ground Plan of Detached Villa—Scale in Fig. 44.

a is the entrance hall, library, and summer sitting-room, entered by the door *d*, lighted by the windows on either side of it; *b b* the inner hall, in which the stairs are placed; *c* the business room, or breakfast parlour; *e* the dining-room, lighted by the windows *w w*; *f* the kitchen. Fig. 43 is the chamber plan, in which *a* is the landing; *b c d* and *e* bed-rooms, lighted by the windows *w w w w*. The bed-room *b* may be made a drawing-room.

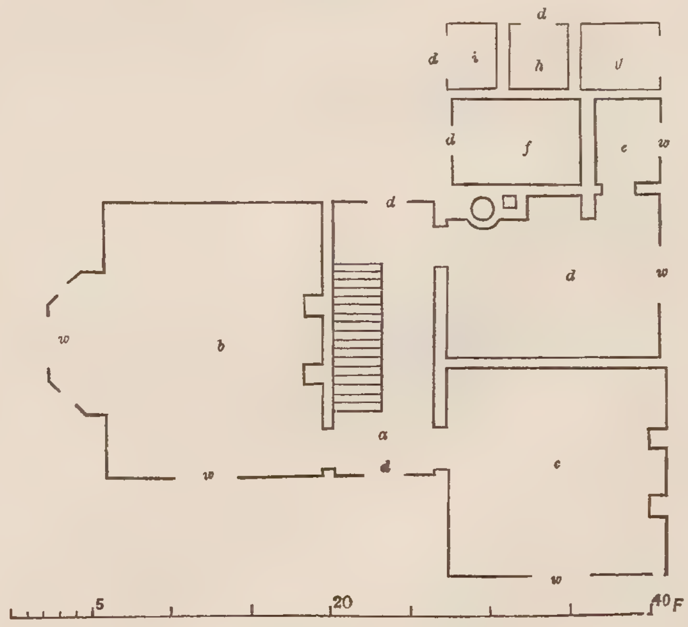
Fig. 43.



Chamber Plan of Villa in Fig. 42.

83. In Plate VI. we give plans and elevations of a detached villa, or farm house. In figs. 44 and 45 we give alternative plans of this. In fig. 44 *a* is the lobby; *b* the dining-

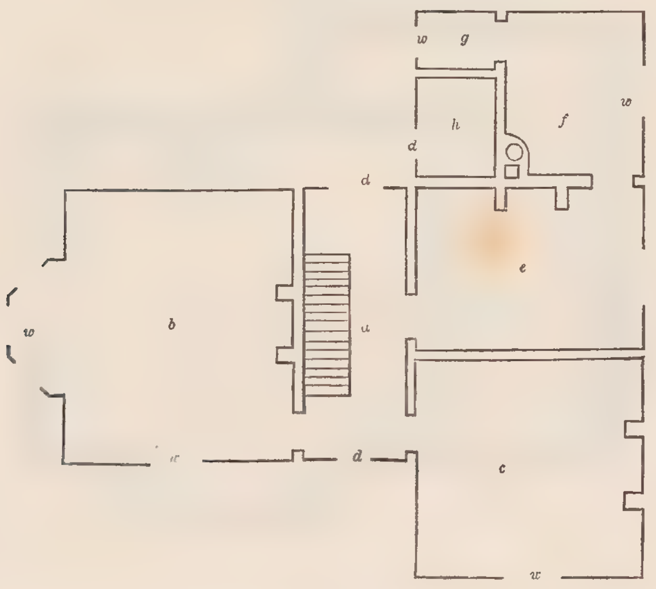
Fig. 44.



Alternative Plan of Villa in Plate VI.

room; *c* the business, or breakfast-room; *d* the kitchen; *e* pantry; *f* coal place; *g* water-closet; *h* ash-house; *i* tool-house. In fig. 45 *a* is the lobby; *b* the dining-room; *c* the business room; *e* kitchen; *f* the scullery; *g* the pantry; *h* coal place. In these plans the letters *d* indicate doors, *w* windows. In fig. 44 there are only three bed-rooms, in fig. 45 four, a small space being taken off the bed-room above the kitchen to give room for a door to enter into the bed-room above the scullery. The plans of chamber floor being almost identical in outline with those of the ground floors in figs 44-45, it has not been considered necessary to give them.

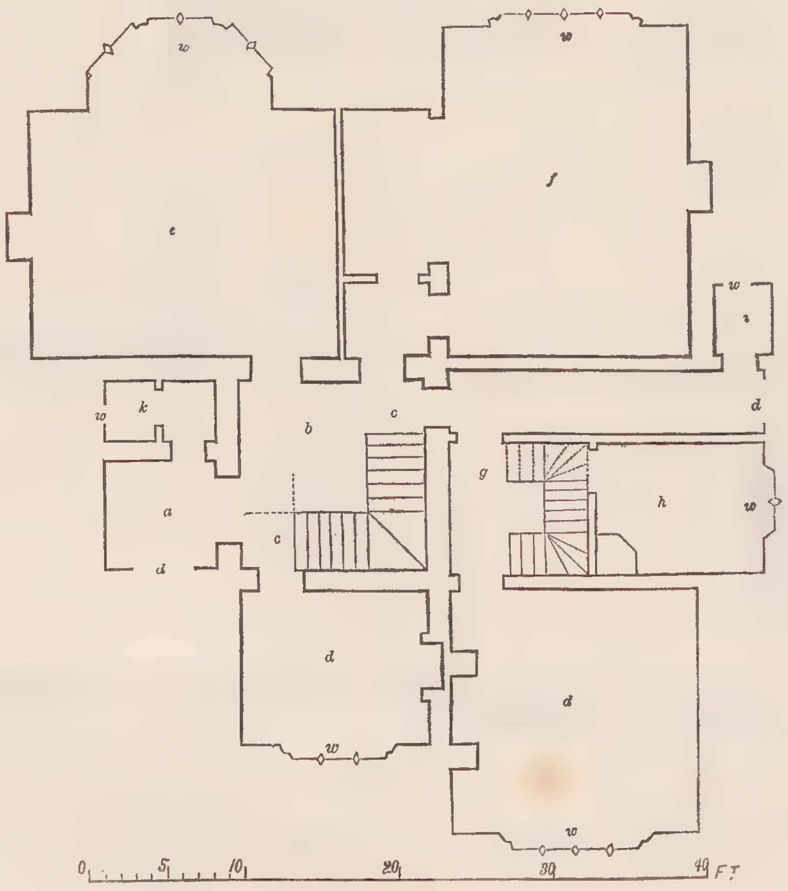
Fig. 45.



Alternative Plan of Villa in Plate VI.

84. In fig. 46 we give the ground plan of a detached villa,

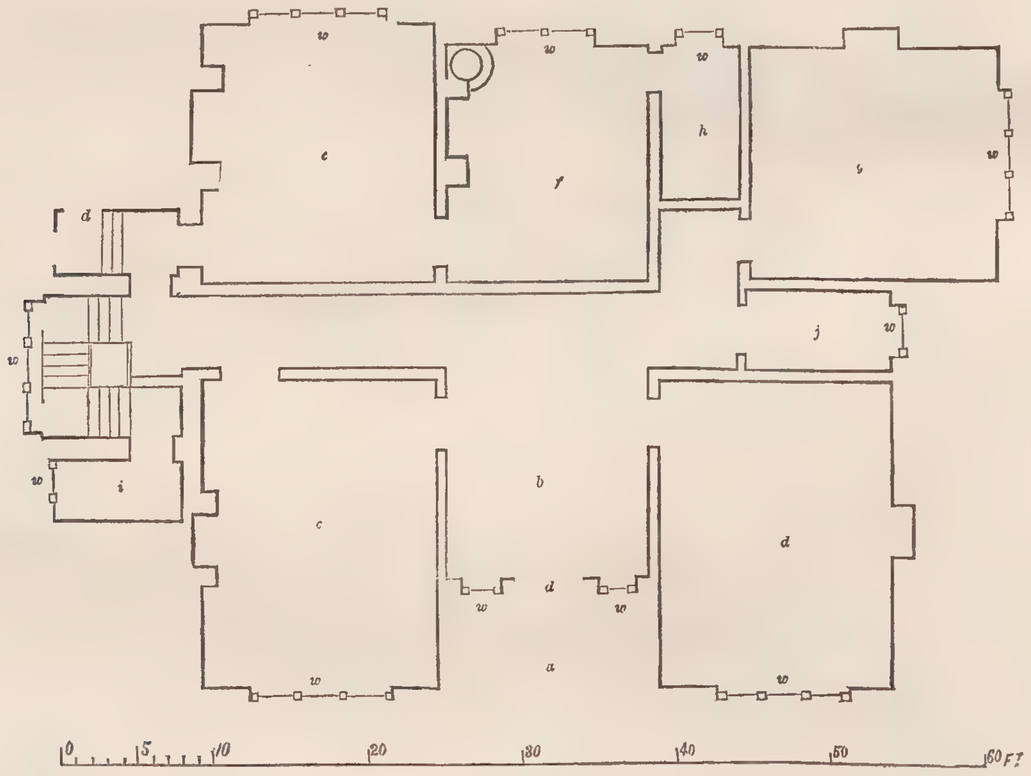
Fig. 46.



Skeleton Ground Plan of a Detached Villa.

in which *a* is the ante-hall; *b* the hall; *c c* the stairs to chamber floor; d the breakfast-room; *e* the drawing-room; *f* the dining-room; *g* back stairs; *l* kitchen; *h* scullery; *k* water-closet; *i* servants' ditto. The chamber plan is almost identical in outline and arrangement with the ground plan in fig. 46, with these exceptions, that the recess in the dining-room is made into a dressing-room, entering from the bed-room above the drawing-room, and the bed-room above the scullery *h*, in fig. 46, has the additional space of the passage *d* below given to it.

Fig. 47.



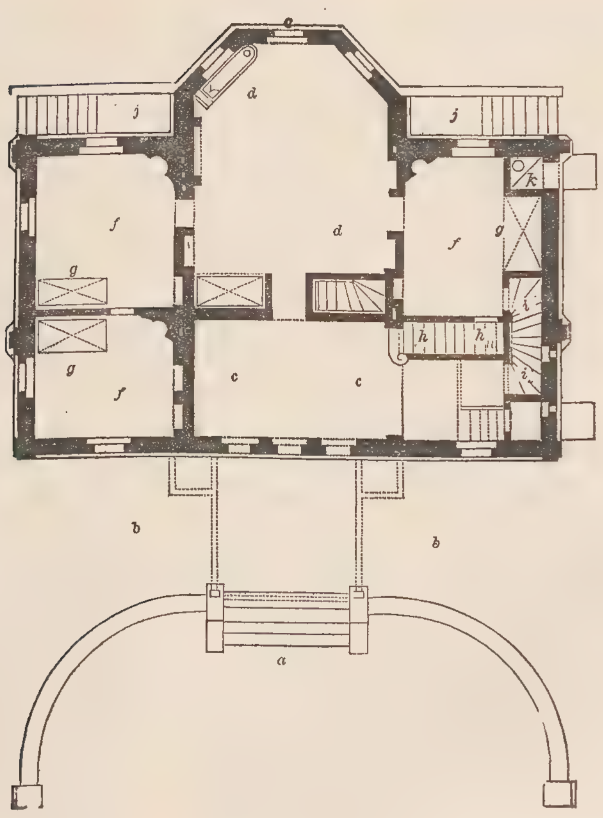
Skeleton Ground Plan of Detached Villa.

85. In fig. 47 we give another outline, or skeleton plan, of a detached villa, in which *a* is the porch; *d* the entrance door, with windows, *w w*, on either side; *b* the hall; *c* the dining-room; *d* the drawing-room; *e* kitchen; *f* scullery, with larder *h* off it; *g* the parlour; *j* china-closet; *i* water-closet. The chamber plan contains the same number of bed-rooms as rooms in ground plan, and arranged exactly in the same way; the space corresponding to the larder *h*, in fig. 47, is made in the chamber floor into a bath-room.

86. In fig. 48 we give the plan of a Flemish or Belgian farm-house, in which *a* is the stairs leading from lawn; *b b* the carriage-drive; *c c* the entrance hall; *d d* the kitchen; *f f f* bed-rooms; *g* shows the position of beds; *h h* stairs to the upper floor; *i i* ditto ditto to cellar; *j j* outside stairs to milk cellar; *k* water-closet.

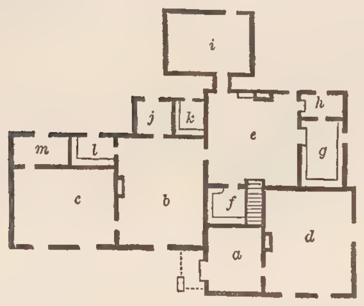
87. In fig. 49 we give the plan of an American farm-house, in which *a* is the hall and library, 11 ft. by 9 ft.; *b* dining-room, 17 ft. by 14 ft.; *d* parlour, 17 ft. by 16 ft.; *e* kitchen, 15 ft. by 14 ft.; *f* the pantry off kitchen; *g* the dairy; *h*

Fig. 48.



Plan of a Flemish or Belgian Farm-house.

Fig 49.

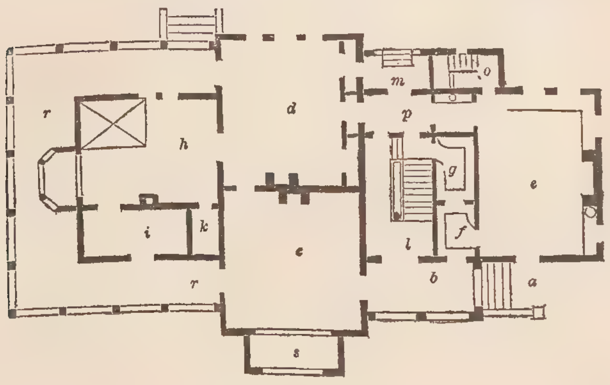


Plan of an American Farm-house.

pantry off ditto; *j* back pantry; *i* wood or fuel house; *k* tool house; *l* pantry off dining-room *b*; *m* ditto off bed-room *c*. The upper story is divided into two bed-rooms, one above *d*, the other above *e*, and a closet above *a*. A third bed-room might be made above the room *b*, in plan fig. 46. For this plan we are indebted to the "Cultivator," an American agricultural journal.

88. In fig. 50 we give the plan of an American villa, or country house, for which we are indebted to the "American Agriculturist," and in which *a* is the entrance; *b* the vestibule; *l* the hall; *c* the parlour; *d* the dining-room; *e* kitchen; *f* pantry; *g* store-room; *p* hall in rear entrance; *o* back stairs; *h* bed-room; *i* dressing-room; *k* closet; *r* verandah. In the chamber floor there are five bed-rooms and a bath-room.

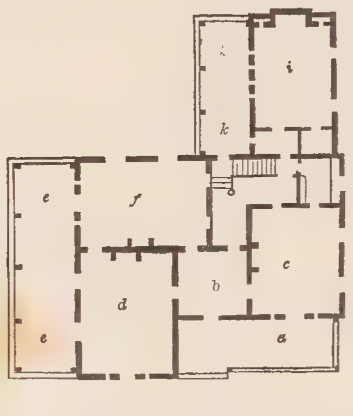
Fig. 50.



Plan of an American Country Villa.

89. In fig. 51 we give the plan of an American country house, designed by Mr. C. Vaux for his work on "Villas and Cottages," and extracted therefrom by the "American Cultivator," from the pages of which we take the drawing. In fig. 51 *a* is the verandah; *b* the hall, 11 ft. 6 in. by 10 ft.; *c* the dining-room, 18 ft. by 15 ft.; *d* the parlour, 20 ft. 6 in. by 15 ft.; *e e* verandah; *f* the library, 20 ft. 6 in. by 15 ft.; *i* kitchen, 17 ft. by 130 ft.; *k k* kitchen verandah; *g h* store-closet and pantry.

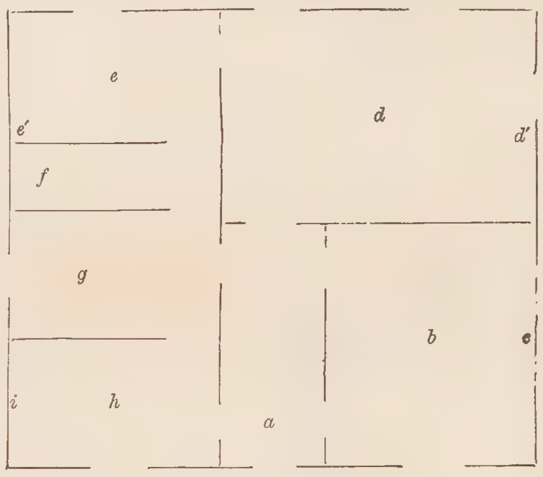
Fig. 51.



Ground Plan of an American Country House.

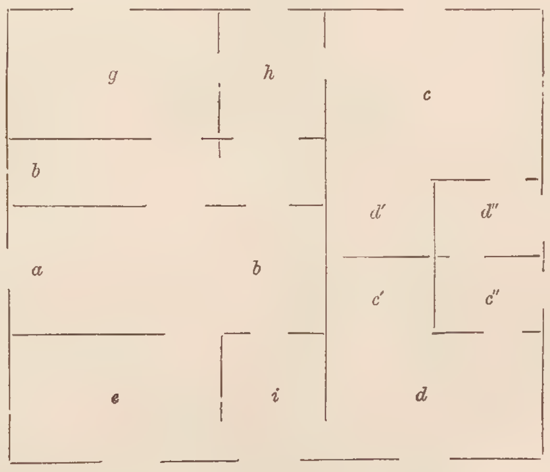
90. As suggestive of some points of novelty and utility in the arrangement of suburban and rural villas, we now give a few type sketches of plans of *French structures.* In fig. 52 we give a ground plan (*plan du rez-de-chausée*) of a French suburban villa, in which *a* is the (*vestibule*) entrance-hall, 2 metres 20 millimetres wide;* *b* the (*salle à manger*) or dining-room, 5 m. ·00 by 3 m. ·70, the position of the fire-place in this room being indicated by the letter *c*; *d* is the (*salon*) or drawing-room, 5 m. 00 by 5 m. ·70, the fire-place being at *d′*; *e* is the (*petit salon*) or parlour, 3 m. ·70 by 2·30, the fire-place being in the corner at *e′*; the (*lieux*) or water-closet is at *f*; *g* the position of staircase (*le cage de l'escalier*), 3 m. ·20 wide by 3 m. ·70 long; *h* is the (*cuisine*) or kitchen, 3 m. ·70 by 3 m. ·20, the position of fire-place being at *i*. In fig. 53 the (*plan du premiere* (1er) *etage*), *a* is the place for staircase; *b* the *anti-chambre;* *c* (*chambre à coucher*) or bed-room, 3 m. ·70 wide; *d* ditto; in these *c′ d′* indicate the posi-

Fig. 52.



Ground Plan of French Suburban Villa.

Fig. 53.



Chamber Plan of French Suburban Villa.

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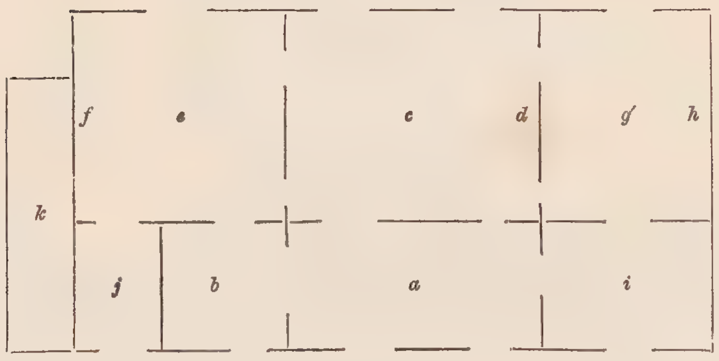
* A French metre is equal to 3 feet 3 inches and 37 seconds of an inch. A metre is written 1·000; a decimetre is written 0·100, and equals in English measure 0 ft. 3″94‴ inches; a centimetre is written 0·010, and equals in English measure 0 ft. 0′·39″ of an inch; a millimetre is written 0·001, and equals in English measure 0 ft. 0·04″ of an inch.

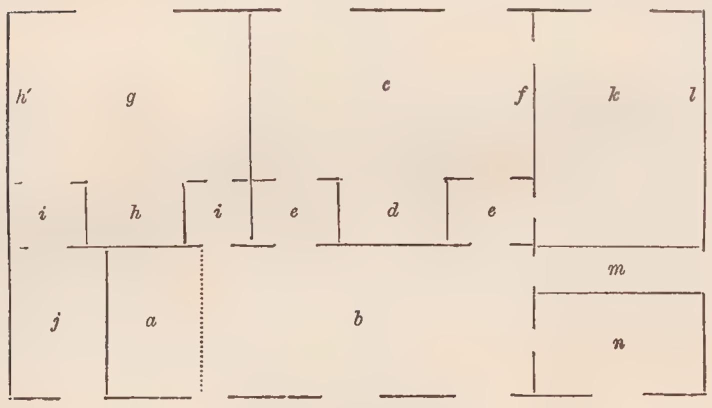
tion of the beds; *c″ d″* closets; *e* a third bed-room, 3 m. ·70 wide; *f* (*lieux*) water-closet; *g* (*cabinet*) or sitting-room, 3 m. ·70 wide by 2 m. ·30; *h* (*cabinet de toillette*) or dressing-closet, ·2 m. ·20 wide; *i* ditto, ditto.

Fig. 54.



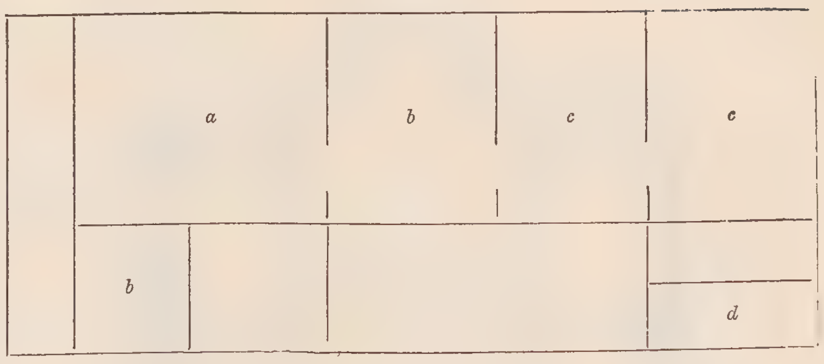
Ground Plan of Villa.

Fig. 55.



Chamber Plan of Fig. 54.

Fig. 56.

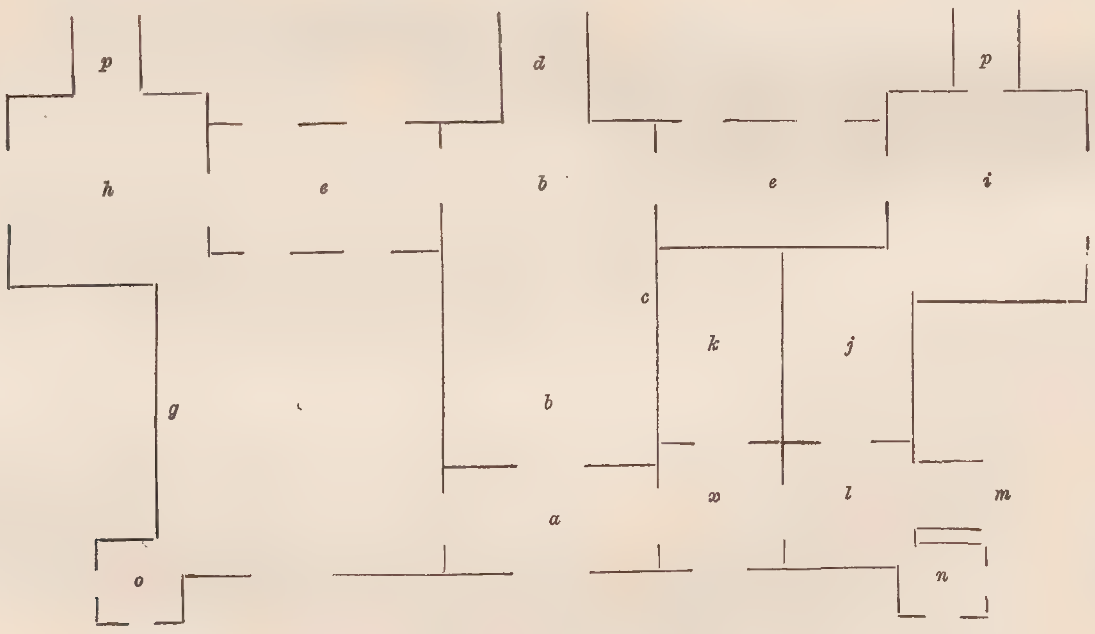


Cellar Plan of Fig. 54.

91. In fig. 54 we give (*plan du rez-de-chausée*) or ground plan of a French villa, in which *a* is the (*vestibule*) or entrance-hall, 3 m. ·20 wide; *b* the position of stair-case; *e* (*salle à manger*) or dining-room, 5 m. ·85 by 5 m. ·65, the position of fire-place is at *f*; *c* (*salon*), drawing-room, 6 m. ·50 by 5 m. ·85, with fire-place at *d*; *g* (*petit salon*), parlour, 5 m. ·85 by 3 m. ·05, fire-place at *h*; *i* (*travail*), work-room or study; *j* office; *k* (*couloir*), passage to (*sous-sol*), cellar—see fig. 56. In the chamber plan, fig. 55 (*plan du* (1^{er}) *etage*), *a* is the position of staircase; *b* the *anti-chambre; c* (*chambre à coucher*), bed-room, *d* showing position of bed; *e e* closets; *f* of fire-place; *g* second bed-room; *h* position of bed; *i i* closets; *h′* fire-place; *k* (*toilette*), dressing-room; *j* ditto; *m* (*lieux*), water-closet; *n* (*bains*), bath-room. In the plan of cellar (*sous-sol*), fig. 56, *a* is the kitchen (*cuisine*); *b b* offices; *c c c* cellars; *d* water-closet.

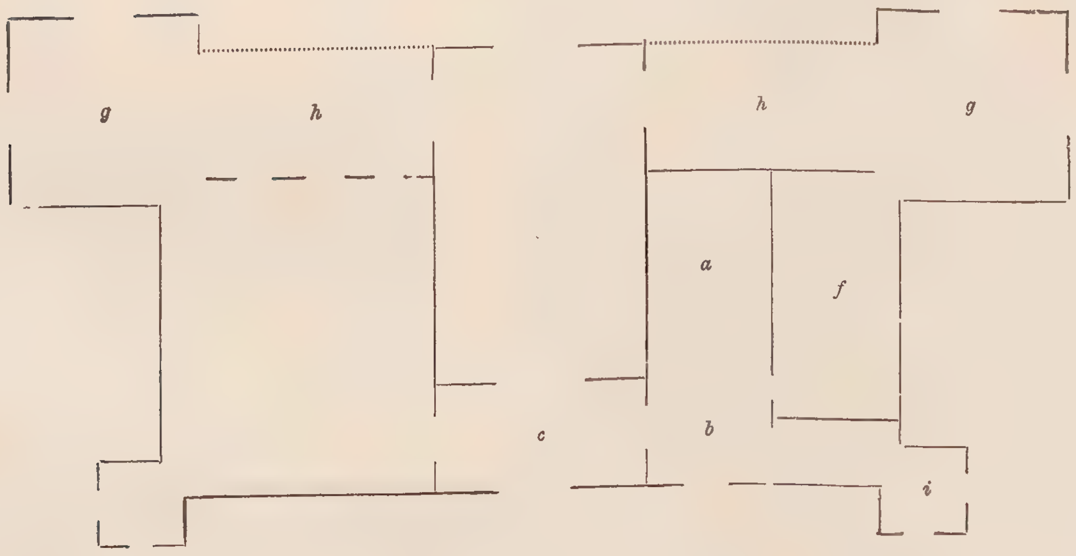
92. In fig. 57 we give ground plan of a French villa, of which *a* is the *vestibule*, 4 m. ·20 by 2 m. ·50; *b* the *salle à manger*), dining-room, 6 m. ·60 by 4 m. ·20, in this *c* indicates the position of fire-place; *d* is a flight of five steps leading to the garden; *e e* the gallery, 1 m. ·80 wide; *f* the (*salon*), drawing-room, 7 m. 00 by 6 m. ·20, in this *g* indicates the position of fire-place; *h* is the (*petit salon*) or ante-room, 4

Fig. 57.



Ground Plan of French Villa.

Fig. 58.

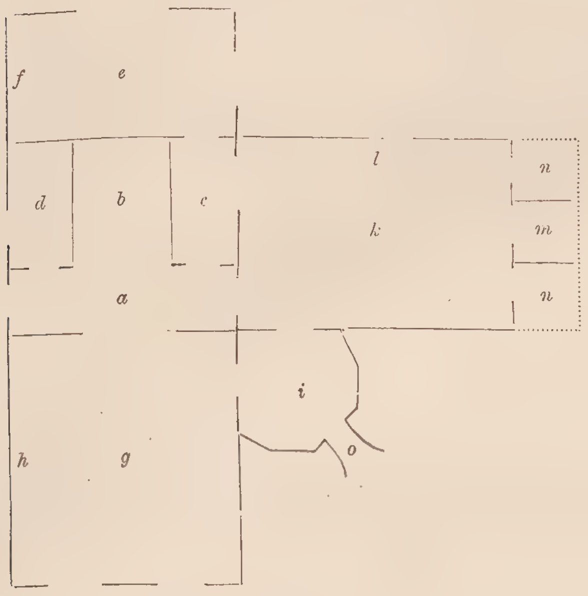


Chamber Plan of Fig. 57.

m. ·20 square, or if round, diameter; *i* is the (*fumier*), smoke-room, same size as *h*; *j* the office, 2 m. ·90 by 4 m. ·50; *k* is the position of staircase, the second story being gained by 16 steps; the width of well-hole is 4 m.; *l* is side lobby leading to the garden by a flight of steps *m*; *n* is the water-closet, 2 m. in diameter; *o* a staircase, 2 m. in diameter, leading to the top of corner tower. Flights of steps, *p p*, lead from apartments *h i* to the garden. In fig. 58, the chamber plan, *a* is staircase; *b* the (*palier*), landing-place; *c* ante-chamber; *d* work-room; *e f* bed-rooms; *g g* dressing-rooms; *h h* terrace (*terasse*); *i* (*lieux*), water-closet.

93. In fig. 59, the ground plan of another arrangement of French villa, *a* is the (*entrée*) entrance-hall, 4 m. by 1 m. ·60; *b* staircase (*escalier*), 2 m. ·50 wide by 3 m. ·20 long; *c* passage to kitchen (*cuisine*), 4 m. by 2 m. ·80, the position of the fire-place is indicated by the letter *f*; *d* water-closet; *g* is the drawing-room (*salon*), 6 m. by 4 m.; *h* is the fire-place; *i* the ante-room (*petit salon*), 3 m. in diameter; *k* the dining-room (*salle à manger*), 6 m. by 5 m. ·10; *m n n* flight of steps, six in number, leading to garden; *o* a flight from apartment *i*. In the chamber plan, fig. 60, *a* is the staircase; *b* (*palier*), the landing-place; *c* water-closet; *d* passage to bed-room *e*; *f* the dressing-closet; *g* bed-room; *h* dressing-room; *i* bed-room; *j* dressing-room; *k* closet.

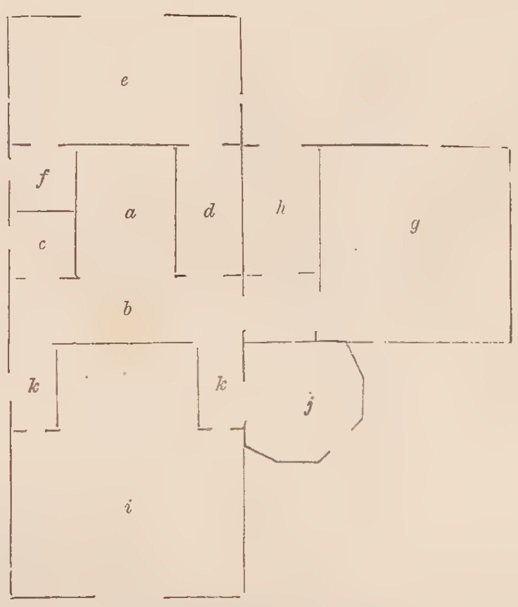
Fig. 59.



Ground Plan of French Villa.

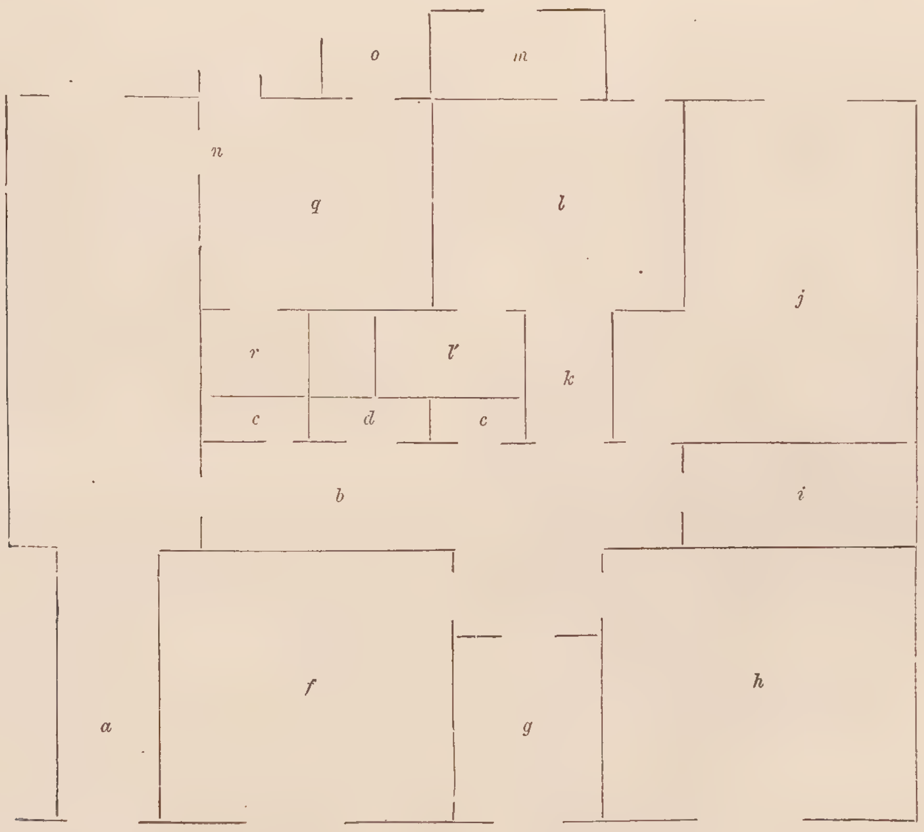
94. In par. 53 we referred to the "flat" system as being carried out to a large extent in Paris, but with modifications which give it a marked distinction from the "flat" system which obtains in Scotland. The extension of this system is ably advocated by Mr. William Chambers, to whose pamphlet on the subject we have already referred. While, however, claiming for the system certain advantages not to be met with in the isolated or self-contained system which obtains in England, Mr. Chambers admits that it has "some disadvantages," which he thus points out. "The chief imperfection is in the arrangement connected with the common stair. Where no more than three or four families—all equally respectable, and with careful domestics—live on the same stair, there is little or nothing to complain of. But in general circumstances, in spite of every remonstrance and attention, the stair is in a less cleanly or tidy condition than would be tolerated by the majority of English housewives. The foundation of the evil is the want of control. Indifferent servants, to save themselves trouble, leave the door open, and beggars and other vagrants readily gain admission. On this account the Scottish system of houses in flats is not to be recommended for adoption in all its integrity unless in special circumstances. It seems to answer sufficiently as regards tenements of a humble class . . but for dwellings of a higher order constructed on this plan in London and elsewhere, I should advise the appointment of a resident porter to take charge of the common

Fig. 60.



Chamber Plan of Fig. 59.

Fig. 61.

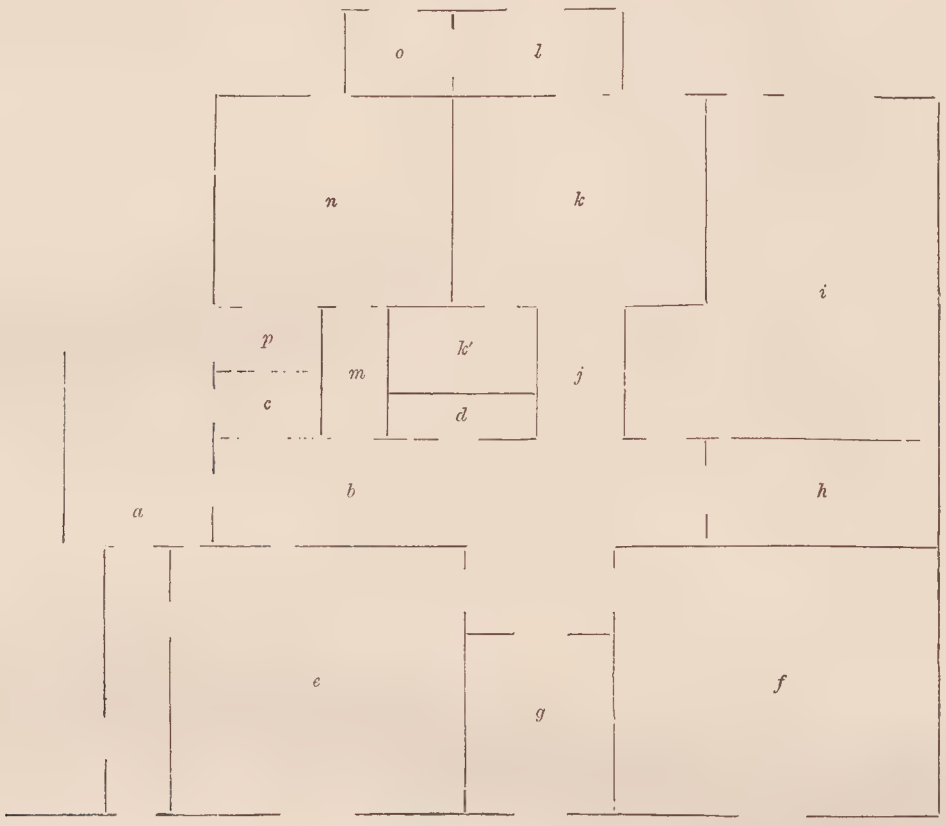


Ground Plan of a "Flat" House, with Porter's House attached.

stair. This person, as is often the case on the continent, might be a mechanic working at his profession in a dwelling within the doorway. Modified to the extent of providing accommodation for this species of guardian of the premises, the Scottish tenement would bear a more close resemblance to that of Paris than it now does, and be in all respects satisfactory to persons of refined taste." This modified system of buildings on the "flat" Mr. Chambers calls by the name of the "Scoto-Parisian system of Town Architecture."

95. In fig. 61 we give a part ground plan of a house built on the flat system, showing the mode of obtaining a "porter's house." *a* is the entrance or lobby giving access to the common stair; *b* the lobby to the left hand ground floor house—off this are the water-closet *c* and the store-closets *d* and *e*; *f* the dining-room; *g* a bed-closet; *h* bed-room; *i* bed-closet; *j* bed-room or drawing-room; *k* passage to kitchen *l*; *l′* servants' bed-closet; *m* scullery. The porter's house entrance is placed at *n*; *o* being a closet; *q* the living-room; *r* bed-closet. The accommodation of the house on the right hand of the lobby *a* is precisely the same as in sketch, with this difference, that the porter's best bed-room occupies the place of the living-room *q*. In the upper stories the space is somewhat differently laid out, as shown in fig. 62. In this *a* is the landing-place; *b* the lobby; *c* the water-closet; *d* store-closet; *e* dining-room; *f* bed-room; *g h* bed-closets; *i* drawing-room or bed-room; *j* passage to kitchen *k*; *k′* servants' bed-closet; *l* scullery; *m* passage to bed-room *n*; *p* closet off it; a larder *o* enters from scullery *l*.

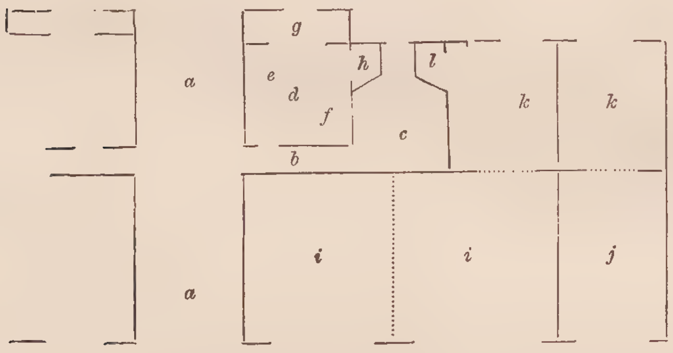
Fig. 62.



Upper Floor Plan of Fig. 61.

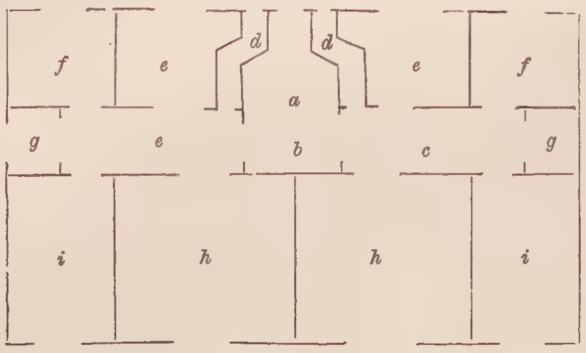
96. In fig. 63 we give the ground plan of a Parisian house on the "flat" system; this is designed by M. Girard of Paris, and is what is termed a "Maison à Loyer," or house let out in floors or apartments, a porter's room being given in the ground floor, the rest of which is taken up with a shop and entrance. In fig. 63 we give a sketch of the ground plan, in which *a a* is the passage; *b* the entrance to stairs *c*; *d* the porter's room (*concierge*); *e* position of fire-place in ditto; *f* of bed; *g* alcove; *h* water-closet; *i i* front shop facing the street; *j* office of ditto; *k k* back apartments to shop; *l* water-closet. In fig. 64, upper floor plan, *a* the landing; *b b* the entrances to the two houses right and left of the landing *a*; *d d* water-closets; *e e* kitchen; *f f* dining-rooms; *g g* cabinets; *h h* drawing-rooms; *i i* bed-rooms. In Plate XXII. the reader will find examples of continental design as applied to houses adapted to this county, and of which the plans will be found in the same Plate. Other examples will be found in figs. 9, 10, 11, Plate II., and in Plate III. One of the principal features in continental architecture is the employment of the high-pitched "Mansard," or "Curb" roof. This gives a good deal of space for attic apartments, and affords the architect an opportunity of introducing picturesque features in the treatment of the roof and its accessories. This style is gradually creeping into favour in this country, as may be seen from some of the recent erections in London. It admits of a bold and striking treatment.

Fig. 63.



Ground Plan of a Parisian "Maison à Loyer."

Fig. 64.



Upper Floor of Fig. 63.

97. Having now given a series of suggestive plans of dwelling-house arrangement, we proceed to place before the reader a few remarks on points of some importance:—*First*, the safe construction of houses through the use of fire-proof appliances; *second*, the prevention of damp in walls, and the use of hollow brickwork in their construction; *third*, the supply of water and contrivances connected therewith; and *fourth*, some points connected with the conveniences and fitting-up of houses.

98. And *first*, as to the safe construction of houses through

the use of fire-proof appliances. It certainly is a somewhat striking circumstance, that, with all our progress in construction, and the use of new and improved materials in connection with it, we have not yet succeeded in introducing a system of construction which shall make our dwelling-houses safe from the ravages of fire. Not that we mean to assert that there is no possibility of so constructing them, but rather that, notwithstanding the existence of modes of construction admirably adapted to secure this desirable end, there is no general adoption of them in this country. In proof of this we have only to note the number of houses erected in this country, with absolutely no provision made to render them safe in this respect, but, on the contrary, with internal construction really most admirably adapted to aid the rapid spread of fire, should that unfortunately break out within a dwelling-house. Need we allude to wooden staircases, roofs, ceilings, and above all, to that most prolific source of danger, the hollow quartering partition, "*any* step from which," says a first-rate authority on building construction, "towards a solid wall is a step towards security." These hollow partitions and cellular ceilings act positively as channels, or fire-ducts, by which the fire is conducted with the greatest possible rapidity from one apartment to the other. No sooner does the heat in any apartment in which fire breaks out increase to such a point that the plaster peels off and exposes the lathing, than these channels or ducts are opened, and the destruction, or at least partial destruction, of the house is a mere question of time. The history of construction—or rather some points connected with it which can be picked up here and there in the records of general history, for a systematic history of construction has yet to be written—shows us some points connected with the use of materials most suggestive to the modern practician. The Greeks and Romans, for instance, paid little attention to fire-proof construction—and, indeed, had not much occasion to do so—from their abundant use of stone and the comparative absence of wood in their structures. But the at once massive and safe erections of the ancients were doomed to be left as mere monuments of their taste and skill, and with the darkness of the middle ages arose a style of domestic architecture and mode of construction exhibiting in its general details what may be called the apotheosis of meanness—for in this, wood was almost the only material used. For their departure from the massive safety of ancient structures the inhabitants of middle age and more recent times suffered fearfully, for whole districts were remorselessly swept away through the ravages of fire. As time progressed, the folly of using such a perishable material began to be understood by our ancestors; and a compromise was made, by which a combination of materials was used in constructing their dwelling-houses; hence arose the half-timbered style of architecture, a style, the details of which carefully carried out, actually necessitated, however strange as it may seem to be, a much safer mode of construction than is often met with in houses of our own day with their flimsy shell of exterior brickwork and their honeycombed interior of perishable timber. Timber was at last altogether discarded from the external parts of structures, but continued to be used, and is now mainly used, as the material for the internal fittings and structure. The change which is at present looming in the future is a change still more decided and characteristic of the day we live in; not a return to the strength and safety of *stone* to which the ancients owed an immunity from the ravages of fire, but to the employment of *iron*. It is a suggestive circumstance, that the use of this material in construction has been brought to its present stage of comparative perfection by continental builders, who have for many years devoted their attention to the subject. They have been ably seconded by the iron-masters—those of Belgium more especially—who succeeded in *rolling* wrought-iron beams and girders of large dimensions at a time when their use was thought of by very few in this country. What we know then of, and practice in connection with, the use of iron in fire-proof construction is derived mainly from the practice of continental authorities, and it is to a brief detail of what they have done that we now propose to devote a short space, supplementing this by a remark or two on systems patented or used in this country.

99. The use of rolled iron in building took its rise in Paris in 1846, in consequence of a strike of the carpenters of that city; and the difficulty first encountered in endeavouring to do away with the use of wood was the obtaining of iron, which at once suggested itself as the substitute made in sufficiently strong yet inexpensive forms. Built beams, made up of several pieces, were obviously too dear, and it was not till after repeated trials that rolled beams in continuous lengths were produced at a rate so cheap as to enable them to be used in almost the cheapest class of houses. Figs. 28 to 43 in Plate XXXVII. illustrate the principal modes employed on the continent, in which rolled iron beams are employed with part success in conjunction with non-combustible materials. In fig. 28 we give a section of a fire-proof floor, in which "I"-shaped beams are used, and of which we give a section in fig. 30 at A′ A′. These girders have a slight camber given to them, and are secured to the walls at the ends by iron straps secured to iron bolts fixed and projecting vertically from the wall. The wrought-iron beams A A, fig. 28, support saddles, or straps B B, made of cast-iron, these passing downwards on each side of the beam. At the foot of the saddles, as B, fig. 29, slots are made, through which are passed flat bars, C C, fig. 28. The distance between these bars from centre to centre being 3 feet 3 inches; the distance between the beams A A, fig. 28, being the same, the floor is thus laid out in a series of squares, 3 feet 3 inches each way. In fig. 29 we give an enlarged view of the beam A A, seen at the side, with the saddle B and iron bar C. In fig. 30 we give a section of the beam A′ A′ and saddle B′, showing the slots D D in the saddle, C′ being the end of one of the iron bars C C, fig. 28. The ends of the iron bars C C, where they terminate at the walls, are secured thereto by iron straps and bolts. The iron bars C C, fig. 28, support square rods of iron D D D. Three of these being placed between each pair of beams, the ends of these are turned down thus ‾‾‾‾| and built into the wall, where they terminate. Under the iron reticulated platform thus formed, a wooden platform is temporarily supported, and the plaster ceiling is formed by being thrown in from above, till the whole of the rods D D, iron straps C C, and the lower part of the beams and saddles A B B, are embedded in plaster. When the plaster is set, the wooden platform is removed and taken to another part till the whole is finished. The floor is made as in fig. 28; joists E E are laid on the tops of the girders A A, these being sometimes let into the lower side of the joists, and on the upper side of the joists the flooring-timbers F F are laid. In place of cast-iron saddles, as B B, fig. 28, wrought-iron straps are used to support the bars C C. In fig. 31 we give a side view of this arrangement; A A the beam; B B the iron strap encircling it; C C the wrought-iron bar passing through slots made in the lower part and secured by the pins D D.

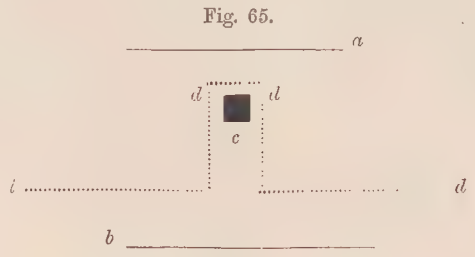
100. In figs. 33 and 34 we give illustrations of another form of fire-proof floor and ceiling introduced by M. Zores, and known as the "fer tubulaire," and of which the following is a description:—The beam is not solid, but is, as its name imports, tubular, being in section of the form as shown at A A, fig. 33. For a bearing of 20 feet the height of this beam is $4\frac{3}{4}$ inches, with a width at top of $2\frac{3}{8}$ inches, at bottom of 4 inches, and with a flange in addition of $\frac{3}{4}$ inch on each side. The thickness of the top and of the bottom flanges is $\frac{7}{20}$ths, and of the top $\frac{3}{10}$ths of an inch. The beams A A, fig. 33, are

placed at distances of 2 feet 8 inches from centre to centre. The bottom flanges support flat bars B B, $\frac{3}{4}$ inch broad and $\frac{5}{10}$ths of an inch thick, these being bolted or riveted at the ends of the flanges, as shown in plan at fig. 34. These bars support iron rods C C C $\frac{3}{4}$ inch square. The joists D D are let into, and are supported by, the beams A A, the flooring-boards E E being supported by the joists, the space between the joists D D and bars B B being filled in with plaster F F. "The girders of this section are said to possess the following advantages over those of the 'I' form commonly used; first, with equal weights, they give a strength or resistance nearly double, as ascertained by the following experiment:—A girder of this form, 20 feet in length, $4\frac{3}{4}$ inches in depth, and weighing 9·5 lbs. the foot, deflected 2·34 inches with a load on its centre of 3 tons. A girder of the I form, 20 feet long, $8\frac{1}{2}$ inches in depth, weighing 16·9 lbs. the foot, deflected 2·49 inches with the same weight. Again, on the score of economy, a floor of 20 feet square, calculated to bear a weight of 200 lbs. on the square foot, exclusive of the weight of flooring, costs in Paris £9 6s. 10d. per square, including everything, when executed with the I-rolled iron girder; and a floor similar in all respects, but having the girder 'fer tubulaire' substituted for the I, costs but £7 9s. 5d. per square. Another great advantage that this form of joist has over that in ordinary use in Paris is, that it does not require any strutting, while the 'I' girder requires lateral pressure to such an extent that it is said not to be employed to the best advantage unless absolutely filled in with either hollow brick arches or plaster, more than half of its strength being dependent on its lateral rigidity."

101. In figs. 40 to 43 we illustrate another method invented by M. Chibon. The beam in section resembles the I or T beam, but is provided with a double flange at top, into which the flooring-beam C C is at once let, in the manner shown in the figs. 42 and 43, a deep groove being made in it. Flat iron bars D D are laid on the lower flanges of the beams A A, and the space between is filled up with plaster E E. The depth of the beam A A is $5\frac{1}{2}$ inches; width of bottom and top flanges, 1 inch; of third or middle flange, $1\frac{5}{8}$ inch wide; the distance of this flange from the top one being $\frac{5}{8}$ths of an inch,—the thickness of the flanges, and of the central web connecting them, being $\frac{3}{10}$ths of an inch. The distance between the girders is 20 inches from centre to centre. This form of girder or beam has, it is reckoned, many advantages, the two upper flanges being so close together as to be almost one, and thus give increased capability to the beam to resist torsion or twisting. "A second advantage claimed for this section of girder is, that it affords a means of laying flooring at once on the iron without the intervention of joists and without the employment of nails, and this is effected in a very neat way by having each end of the oak batten—of which the parquet, or French flooring, is formed—ploughed with a tolerably deep groove, into which the top flange of the girder fits, the lower side of the batten resting on the second or broad flange, and its upper surfaces meeting over the centre of the top flange, which is thus effectually hidden; and this method is not only more economical in the first instance, but has the additional advantage of rendering it impossible for any board of the floor to get out of level or start up, and also to give the means of removing the whole or any part of the floor at any time and relaying it without the slightest injury, and also of tightening it up in case of any shrinkage of the wood. The facilities for laying a floor in this way are much increased by the French method of flooring with oak in short lengths, and in a kind of herring-bone pattern, called 'point de Hongrie.' As to the expense, the following is the cost of a square of flooring in Paris, executed in three different ways, viz.:—In wood, £8 12s. 6d. for a square; in double I iron beams, as in fig. 28, Plate XXXVII., £9 17s. 0d.; and in the 'à fer à coulisse' system, illustrated in fig. 40, Plate XXXVII., £5 17s. 3d."

102. Another method largely used on the continent is illustrated in fig. 39, Plate XXXVII. In this A A A are wrought-iron plates, between which are suspended the bars B B, the ends of which are bent so as to embrace the upper edge of the beams A A. On the bars B B the cross-bars C C are placed, the whole forming an iron platform. A modification of this plan consists in using I girders or beams, in the line of neutral axis of which iron bolts are screwed. These afford suspending points for iron straps, similar to B B in fig. 39, Plate XXXVII., the straps being continuous; this is illustrated roughly in the diag., fig. 65, where *a b* represent the upper and under sides or flanges of the beam or girder, *c* the bolt in the line of neutral axis, *d d*, *d d*, the iron strap or bar bent round the bolt at *c*. The horizontal parts of the bar *d d* support the small cross-bars corresponding to C C, fig. 39, Plate XXXVII.

Fig. 65.



103. An iron girder, or brestsummer, on the built principle introduced on the continent from the iron-works of Creuzot, is illustrated in figs. 35 to 38, Plate XXXVII. The brestsummer is made up of two side plates of wrought-iron, A′ A′, fig. 38, Plate XXXVII., 9 inches deep by $\frac{3}{8}$ths of an inch thick, kept 12 inches apart by top and bottom pieces, B′ B′, which fit into rebates made in projecting parts, as shown at the upper and lower edges of side plates A′ A′. The whole are kept together by an iron band or hoop, placed at intervals of 12 inches along the length of the girder. At points corresponding to the centre line of these hoops, are cast-iron frames, one of which is shown at D D D D in elevation in fig. 35, and two in section at D′ D′ in fig. 37. Fig. 36 is a side or edge view of the hoop, and fig. 37 an inside view of the brestsummer A′ A′, the side plates corresponding to A A in fig. 35; B′ B′ the top and bottom plates to B B in fig. 35; D′ D′ the cast-iron frames; and C′ C′ the hoops or bands.

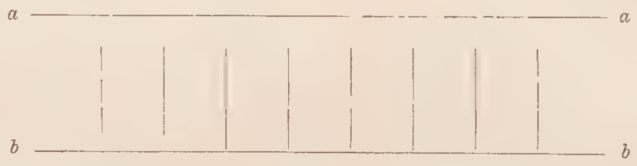
104. We now propose briefly to describe modes of fire-proof construction patented in this country, and of which the first we notice is that which has been, perhaps, the most extensively carried out, viz., that of Fox & Barrett, and several forms of which we illustrate in Plate XXXVII. In fig. 1 a simple modification of the principle is shown, in which A A is a rolled iron joist, supported upon double I beams B. E E are the filling-in pieces resting upon the lower flange of the joists A A. The concrete I is filled in above, and rests upon these, and fillets C C are imbedded in the concrete, upon which the flooring-boards rest, and to which they are secured.

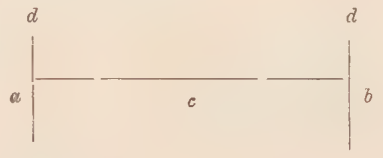
105. In figs. 16 to 21 we illustrate Bunnett's (Deptford, Kent) patented method of fire-proof construction, the main feature of which is the employment of hollow or cellular bricks, figs. 16, 17, 18, Plate XXXVII., having indented or rebated sides, so that the bricks, as they are placed together, lock or dovetail into each other. The bricks are laid to break joint with each other, and so that each brick receives the support of six adjoining ones; the principle of mutual support is thus carried out over the whole floor. The ends of the arches or floors, as in figs. 19, 20, and 21, Plate XXXVII., are made to rest upon angle irons, B B, E, supported by the wall A A, and kept in position by tension-rods passing through the arch, as at C C C′, fig. 19, or under the arch, as C in fig. 21, Plate XXXVII. These tension-rods are either secured to the angle iron shoes, as at B B, figs. 19 and 21, or passed through the wall and secured by bolt and nut, as at F in fig.

20. The floors are thus made to rest equally upon the walls; and as they are built in as the walls are carried up, all unequal settlement is prevented. One advantage presented by the flooring in this system is the hollow spaces provided, by which warming and ventilation can be easily carried out. On the floors of hollow bricks thus constructed ordinary flooring-boards or encaustic tiles may be laid if required. Fig. 19, Plate XXXVII., represents a floor adapted for ordinary dwelling-houses. A the wall, B the angle iron shoe, C C C′ the tension-rod passing through the hollow bricks D D. Fig. 16 represents a cross section of a brick, and fig. 17 a longitudinal section of the form used in fig. 19, one-eighth full size. The under sides of these bricks have dovetail grooves, which afford keys to the plaster ceiling. The under side of the ceiling is slightly arched, which affords facilities for ventilation; for, by boring or providing apertures in the lower sides of a few of the bricks, and placing these in the centre of the ceiling, the foul air, or heated products from the gas, will be led off at once into the channel formed by the bricks, and may be passed into a flue made in the wall, or into a ventilating duct. While the ceiling is being plastered, plugs may be inserted into the holes, and withdrawn after the ceiling is finished; this will prevent the apertures being filled up. We are inclined to suggest this way of providing a few of the cellular bricks as a very important and simple mode of effecting the ventilation of rooms in which ceilings on this system are used. Fig. 20, Plate XXXVII., illustrates a fire-proof floor for a warehouse, the tie-rod of which, D, passes under the ceiling, and forms supports for the ceiling-joists if required. The arrangement illustrates a method of applying the principle to existing buildings, brick beam being made to rest at the ends upon projecting brackets let into the walls, the tie-rods being carried through and secured, as shown at F. Fig. 21 illustrates a floor perfectly flat throughout its length, and on which boarding, plaster, tiles, or parquet, may be laid. Fig. 18 illustrates a cross section ($\frac{1}{8}$th of an inch scale) of a cellular brick adapted for this floor.

106. In Essay Third we have described the principle of Mallett's buckled plates; in figs. 22 to 27, Plate XXXVII., we illustrate the principle as applied to the construction of fire-proof floors and partitions. In fig. 21 we illustrate a fire-proof floor for a warehouse; A A space filled up by hollow brickwork, of which sections are shown in fig. 23, which is a transverse section of fig. 22 in the line B C; D D concrete lying upon the buckled plates F F, these being supported by, and secured to, the wrought-iron beams E E; H H the timber boarding of the floor. In fig. 24 we illustrate a fire-proof partition, in which A A are the buckled plates; B B the cross wrought-iron ties or beams, the spaces between the buckled plates being filled in with concrete. In fig. 25 we illustrate a fire-proof floor for manufactories. A the iron pillars or columns of the building; B the wrought-iron girders; F the buckled plates; E concrete; C hollow bricks resting upon the crown of the buckled plates and supporting the flagging of the floor. A space is left beneath this for ventilating and heating purposes. In fig. 26 we illustrate a fire-proof floor for ordinary dwelling houses. A A A the wrought-iron beams; B B B small timber joists; C C the timber flooring; D D the buckled plates; E sawed lath; and F plaster ceiling. Fig. 27 illustrates a fire-proof floor for ordinary dwelling-houses, in which plaster ceilings are dispensed with, and the buckled plates form the ceiling. A A A the iron beam, carrying the buckled plates; B B B, C C C, the concrete, on which rest the timber joists; D carrying the flooring-boards. It is obvious enough that this—what we may call the happy—invention of buckled plates is capable of being adapted to a wide variety of purposes in building construction.

107. Such may be taken as descriptive of the most important of the leading plans in use on the continent and in this country, patented, or requiring special adaptation. Fire-proof construction, on a less pretentious and yet positively secure system, may still be carried out to a fair point of efficiency by the use of materials, and on a plan so simple as to be within the easy reach of even the humblest of constructors. To a notice of some of the plans proposed and partially practised in this country, and to those which have for a long time been practised, and practised exclusively, on the continent, we now devote a brief space. So early as the middle of the last century, Earl Stanhope—so well known for his ingenious inventions—introduced a method of fire-proof construction eminently simple in its details, and which trial proved as eminently efficient in practice. The main feature of the Earl of Stanhope's system was the use of a non-conducting material applied to the beams of a house. This was made by cutting hay into 3-inch lengths, and mixing this with three measures of common sand and two of slaked lime, dragging the hay well through the mixture, and the whole being left as stiff as possible, but yet thin enough to be laid on with facility. This non-conducting substance was then laid over the surface of the joists, and after it was thoroughly dry, short pieces of laths were nailed vertically to the sides of the joists, as shown in the following rough diagram; these laths were stopped short of the upper side *a a* of the beam by the space of $1\frac{1}{2}$ inch, but were flush with the under side *b b*. On the top of these laths short pieces of laths were placed, as *c* in the diagram (*a b* representing the outside of the beams), forming a species of floor, on which was laid a layer of the non-conducting material, filling up the space from *c* to the upper edge of the joists *d d*. In a house fitted up with fire-proof floors of this nature, and specially filled with combustible matter and set fire to, the heat was so great as to cause the glass of the windows to run like wax, yet the "flooring-boards of that very room were not burnt through, nor was one of the side timbers, floor-joists, or ceiling-posts, damaged in the slightest degree, and the persons who went immediately over the room filled with the fire did not perceive any ill effects from it whatever, the floor of the room being perfectly cool during the enormous conflagration immediately underneath." It is right, however, to state that the plan we have above described was modified in this trial, so that by what was called "extra lathing," a thicker layer or body of non-conducting substance was provided. This extra lathing consisted in applying a thick layer of the non-conducting substance to the outside of the laths, which we have already described as being applied to the sides of the joists, and in this thick layer embedding other laths and securing these by nails, thereafter applying to this second set of laths a third layer of the non-conducting substance.





108. The use of a non-conducting material thus introduced years ago by the Earl of Stanhope is still the distinguishing feature of nearly all modern plans, and specially of those extensively practised by the Parisian builders, and which we now briefly describe. To the under side of the timber-joists a series of laths are secured, with spaces left between each. A platform is arranged so as to be beneath a portion of this lathed surface, and to leave a space of an inch or so between the under side of the laths and the upper surface of the

platform. Mortar—having in its composition a large proportion of plaster of Paris, in order to make it set quickly and hard—is then forced into the space between the laths and the platform, or forced from above between the spaces of the laths. The mortar is thus spread evenly under the laths, and forcing itself over the upper sides, overlaps, and thus secures a firm hold of them. As soon as the mortar is set, the platform is removed to another part of the ceiling, and the process is carried on till the whole surface is done. The same principle is applied to the formation of fire-proof partitions. The spaces between the uprights are filled in with any sort of rough scantlings, and so as to form a species of honeycombed, or celled space. On one side of the partition thus formed a flat board is placed, and the mortar is forced in between the filling-in spaces, and passing out between the outer side of the partition and the inner side of the platform—the space between these being about 1 inch—overlaps the uprights and the filling-in spaces. The other side is then finished by hand, and when the mortar is fairly set, the timber is so imbedded in the mortar that it is next to impossible to set fire to it. The principle is also applied to the under sides of staircases, which are thus so imbedded in mortar that they are equally impervious to fire; the result of the whole being that an almost absolutely fire-proof house is obtained, and at a cost within the reach of all, and available by a method so simple as to be carried out by the humblest builder provided with but the most inexpensive of appliances. We could say more upon the subject—which is undoubtedly one of the most important connected with house construction—but we have said enough, surely, to show that where fire-proof construction is really desired it is easily enough obtained. It will be long, however, we much fear, before the apathy of house proprietors, or the prejudices of house-builders, are so fully overcome as to prompt the one to desire, and the other to carry out generally, even the simplest and most inexpensive of the plans we have described to the reader. It is surprising how difficult a matter it is for one to break through established practice and take the position of an innovator, of which character, however useful it has been in the history of our material improvement, many seem wonderfully indifferent to assume. It may be difficult to credit the statement, but we believe that it is simply a fact, that notwithstanding the awful warning the proprietors of the well-known warehouses in London had in the destruction of their property, with contents, by a fire, which, for its unexampled fury, and for the enormous loss sustained through it, will be recorded as one of the striking facts of the century, they have nevertheless rebuilt them, or had them rebuilt, on a plan showing a supreme indifference to the adoption of any complete and perfect plan to prevent fire committing a similar devastation.

109. We now come to the *second* of the divisions yet to be noticed, namely, the "prevention of damp in walls, and the use of hollow brick-work in their construction." In Essay Sixth we have stated that the only true mode to secure dryness of the walls of a house is to thoroughly drain its site. Even where this is done, however, it is advisable to carry out other modes in general use, namely, by laying a course of slate or lead bedded in hydraulic cement, or in tar and sand, at the top of the foundation. This mode alone will not, however, secure dryness in the wall unless carried out in conjunction with the drainage of the site. In place of using a layer of slate, as above described, we would be inclined to recommend the use of Taylor's foundation bricks, a description of which will be found in Essay Eleventh. In stone houses it will be essential, if foundation dampness is to be got rid of, to lay the foundation in a bed of concrete, and set the lower course throughout, in hydraulic mortar.

110. Damp, however, not only affects walls by rising from the foundation, but by passing from the outside to the inside, long-continued battering blasts of rain very rapidly saturating the walls. In the case of stone walls, the only efficient remedy for this cause of dampness—which cannot be avoided—is to avoid laying the interior plaster directly upon the walls, firring off a space with timber battens and laths between the wall and the plaster, or, what is still better, running up a lining of brickwork, brick thick, and bonded to the wall at intervals by headers let into the stone wall. The Rev. Mr. Stewart has introduced a form of hollow brick which has been used with remarkable success for lining walls or forming partitions. This we illustrate in fig. 1, Plate XXXI. In fig. 2 of the same plate we give a section of Hertslett's patent hollow brick, which, upon the cellular and dovetailed principle, is not only strong and easily bonded together, but is well adapted for its lightness as a lining for stone walls or for the formation of fire-proof partitions. Mr. John Taylor, architect, of London, has patented a very ingenious mode of *facing stone walls*, either externally or internally, with stone slabs cut out in the method shown in fig. 3, Plate XXXI. When applied to walls, no iron cramps, ties, bond stones, or other artificial aids are required. Fig. 4 shows the mode of applying the facing-blocks—made of superior clay—to brick walls. The wall is constructed in the usual manner up to the underside of the flange or rebate of the facing A, which is fixed thereon, having mortar under its flange or rebate, and fine mortar between the face joints. The course of the headers B and closers C are then laid, and the course of brickwork above. Mortar, D, is put as a key upon the top of the flange or rebate A. These mortar-joints, D, being less in number than those of the brickwork, are thicker, and can never become set or dry so soon, thus perfectly compensating for the more numerous of the brickwork, and preventing all injurious weighting of the facings in consequence. The section B, fig. 5, Plate XXXI., shows the wall constructed with a hollow space between it and the facing. It can be either faced at the same time or afterwards. Fig. 6 is an isometrical view of the system as applied to a brick wall.

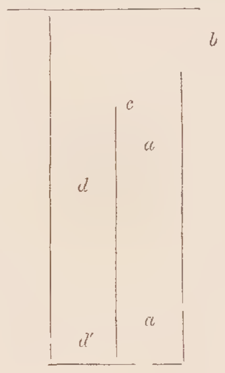
111. In the construction of brick walls there are modes of working more readily applicable than in the case of stone, by which dampness in walls may be avoided, and at the same time other advantages obtained; we refer to the system of *hollow brickwork* construction. The advantages of the system are made manifest in the dryness of the walls built in accordance with it, in the saving of bricks and of mortar, and the saving also of interior lath and studding, the plaster being laid at once upon the bricks, which are either made to project—thus affording a key to the plaster—as shown in the mode of construction in fig. 8, Plate XXXI., or are left flat, as in fig. 7, same plate, Fig. 7, Plate XXXI., illustrates a *nine-inch* hollow wall on the principle introduced by Mr. Dearn in this country. The lower courses are laid in ordinary English bond; the course commencing the hollow brickwork is made by placing two rows of stretchers on edge; the next course is one of "headers" laid across; the third is one of stretchers similar to the first, and so on. Fig. 8 illustrates an *eleven-inch hollow wall;* in this the headers are placed within the stretchers a distance equal to 2 inches, so that the stretchers project beyond the headers, affording a series of spaces into which the plaster can key, or by placing a vertical series of studs or fining on the face of these projecting bricks on which the lath plaster can be laid; a *double* hollow wall can be obtained. In fig. 9, Plate XXXI., we illustrate a *twelve-inch hollow wall*, constructed by two stretchers and a header, placed alternately on both sides of the wall, thus leaving a series of spaces, each two of which are divided by the projecting part of the header. In the next course the headers are alternated, so that the joints of the two stretchers are

covered by them. In fig. 10 we illustrate a *sixteen-inch hollow wall.* In this there are two courses of bricks towards the inside, the single course being inside. The tie-bricks are marked *a*, and, as will be seen from the plan of second course in fig. 11 (fig. 10 being the plan of the first), these tie-bricks alternate in the courses so as to secure a good bond. As will be perceived from fig. 10, the outside bricks of the first course are formed with stretchers, the inside bricks being a stretcher and a closier alternately. In the second course, shown in plan in fig. 11, the outside course is made up entirely of a series of headers. The wall will thus be built up in English bond, having alternate courses of stretchers and headers.

112. In place of building walls with solid bricks, but so arranged to be hollow as we have just now described, bricks in *themselves hollow* are largely used for making hollow walls. In fig. 12, Plate XXXI., we illustrate forms of hollow bricks introduced by the "Scottish Association for the Improvement of the Condition of the Agricultural Labourer." Fig. 13 illustrates a hollow-grooved stretcher brick, and fig. 14 a header, manufactured by Norton & Borrie. Fig. 15 illustrates a cross section of a nine-inch wall made up of the hollow bricks patented by Mr. H. Roberts of London, and fig. 16 an elevation of the same. The peculiar feature of Mr. Roberts' system is the doing away with all headers and vertical joints.

113. Hollow blocks, cement, or artificial stone are now being introduced into practice for the building of walls in a cheap and ornamental form, and perfectly free from damp. A continental architect has patented a most ingenious mode of forming blocks of cement, which are said to be as solid as stone, and "incontestably superior to the ashlar used in the construction of thick walls;" they are capable of resisting 430 lbs. to the square inch. We owe to the pages of the "Building News" the illustration in Plate XXXI. Fig. 17 illustrates a sectional plan of a hollow wall formed with these cement blocks, this being made up of pieces of the forms shown in fig. 18. The "under courses are marked by oblique shading lines, while the upper are left white, and the openings ruled perpendicularly." Fig. 19 illustrates the method of forming partition walls of these cement blocks. Fig. 20 illustrates a mode introduced in this country of forming walls of solid blocks, by which a double hollow is secured.

114. The rapid drying of houses is often a matter of great importance, and the difficulty of doing it quickly by means only, of the ordinary fire-grate is such that other means have been attempted to be introduced. In connection with this subject of drying the walls of apartments, we may notice here a very ingenious mode of using a chemical substance, prepared by Mr. Desmond G. Fitzgerald. The material used is a *chloride of calcium.* The problem of drying the air within any enclosed space without the use of artificial heat is stated to be most easily solved by the use of this material. It is cheap, gives out no noxious effluvia, and is easily applied. It has long been known to chemists as a valuable means for depriving gases of moisture, but the difficulty of applying it in practice in the way above described has been great, in consequence of its liability to overflow the vessels in which it is contained, and also from the difficulty of freeing it from its absorbed moisture so as to make it again available. These difficulties have been obviated by the method proposed by Mr. Fitzgerald, in which a tray of sheet iron forms the material (chloride of calcium); this is furnished with a small reservoir of oil below the level of the outer rim. As the drying material absorbs water from the substances with which it is surrounded, or from the atmosphere, so as to pass the level of the oil reservoir, a portion of the oil is displaced, and as a film covers the solution, thus completely obviating all danger which might arise from non-attention to the overflow of the contents of the iron tray. A wire trellis cover is made to the tray, so that the material can be safely subjected to the heat of the fire, the moisture expelled, and the material again ready for use. The following diagram illustrates the application of this drying material to the side of a drying-house. *a a* the case in which the chloride of calcium is placed, the air entering at a branch perfectly dried, and is again diffused into the room deprived of its moisture, which is absorbed by the material *a a*; as it liquefies it flows over the edge *c* into the reservoir *d*, in the bottom of which is a small portion of oil at *d'*, and a portion of which is displaced, covering the surface of the solution, and preventing further absorption.



115. We now come briefly to discuss some points connected with the "supply of water, and the contrivances connected therewith" (see par. 97). Much of what we have to say on this subject has of course special reference to villas and houses built in the country, or in suburban districts, where the water is not supplied at pressure, or on the "constant supply" system, but is obtained from wells specially dug. Where water is laid on at pressure from the town's water-works, the fittings are reduced to the maximum of simplicity, and all those considerations as to choice for position of well, &c., are dispensed with and avoided. Our remarks, therefore, will be divided naturally into three divisions—the kinds of water used for domestic purposes; the modes of obtaining a supply in rural and suburban districts; and the fittings requisite to convey this supply to the house, and to free it when necessary from impurities.

116. Water may be divided into two great classes, hard and soft—these being obtained from various sources, as rain, rivers, and springs. Rain-water falling through an atmosphere not greatly contaminated by impurities, as soot, &c., is the softest we can obtain; falling through a clear atmosphere is the purest—in fact, the nearest to distilled water. Water flowing over a chalky soil, or passing through chalky strata, is generally hard. Nearly all authorities agree in stating soft water to be in every way superior to hard, not only for the purposes of cooking and drinking, but for washing. As regards the influence it has upon the health of those using it habitually, much interesting information has been collected. Hippocrates takes notice of the deleterious influence exercised upon the general health by the habitual use of hard water. The value of soft water for various purposes is also noticed by Lord Bacon. Dr. Heberden, in a paper (read before the College of Physicians in 1767) on the subject, gives the following suggestive hint:—"The uninterrupted drinking of such water (hard) for a long time may probably be the cause of many other disorders, especially to the infirm and to children; *hence a change of place may often be of as much use to weak persons from the change of water as of air.*" Dr. Todd Thomson, in his work on the domestic management of the sick room, says that "rain water or distilled water" are the only kinds proper for the use of the sick-room. Hard water, under whatever name it is found—whether as spring-water, or pump-water, or well-water—should be excluded." It is interesting to trace the high estimation in which soft water is held in foreign countries. Sir George Staunton, in his "Embassy to China," states that "persons of rank in China are so care-

ful about the quality of the water they intend for their own consumption, that they seldom drink any without its being distilled." Pizo says (De Medicin. Brasil. 1640) the old men of Brazil are as nice in their choice of water as people are with us in distinguishing the qualities of wine, and they accuse persons of imprudence who use them all without selection. Bruce, in his Travels in Abyssynia, states that in Egypt they prefer the water of the Nile. The gravel is said to be "universally the disease with those who use water from the draw-wells, as in the desert." It seems almost certain that hard water tends to induce that dreadful malady, the stone; at least its use tends to aggravate the disease. But the influence of soft water in cooking and washing is also as marked, nay, more so, than upon health. The use of soft water effects a large saving in the making of tea, so that, as M. Soyer demonstrated by means of it, five cups of equal strength could be obtained where three only were obtained by the use of hard water. In all kinds of cooking soft water is very much more useful than hard, not only rendering the substances more tender, but bringing out their peculiar flavour. As regards its use in washing, those who have used it once for the purposes of personal ablution, will never again use hard water if they can avoid it, so pleasant is soft water in its effects. In the washing of clothes, so wasteful is the use of hard water, that it has been calculated that the sum expended through the wear and tear and waste of soap, equals the amount expended in their purchase. Rain-water is, as we have stated at the commencement of this paragraph, the softest we can obtain; and it behoves every one so to arrange some appliance in connection with his house by which the rain-water from the roof can be stored up for daily use, and in connection with this we now offer a few remarks.

117. Rain-water may either be stored up in a cistern placed below the roof of the house at such a height as to supply the water-closet on the bed-room floor at pressure; or, secondly, the cistern may be placed on the roof of the scullery or outhouse; or, thirdly, the cistern may be made in the ground tank-fashion. Of these three methods the first is the most seldom adopted; in this a small cistern is placed on the roof to hold sufficient water for the supply of the water-closet only, the supply for domestic purposes being obtained from the cistern placed either in the second position above noted—the way commonly used—or in the ground. A little may here be said as to the mode of construction of cisterns placed in the first or second of the positions noted with reference to the influence upon the water of the materials with which they are lined. The substance generally used for lining cisterns is lead. Scientific researches have apparently resulted in making the opinion to be almost *universally* held, that the action of water upon lead is dangerous. The following may be taken as a *resumé* of the result of the scientific inquiries made on the subject:—Air and moisture oxidise lead. The first chemical formation induced by the action of pure water upon lead is a *hydrated oxide*. This chemical change is effected much more rapidly in open vessels exposed to the atmosphere than in closed ones. A circumstance to which an able authority attributes more than to any other cause the speedy formation of this hydrated oxide of lead in water-cisterns lined with lead, is the continual changing of the water-level, thus exposing the lead to alternate changes of wet and dry, and to air as well as moisture. That the formation "is much influenced by evaporation there can be no reasonable doubt—in proof of which," continues the same authority, "we find that where the water of a cistern is kept at the same level by constantly adding as much as is taken away, thin lead will soon be cut through at the *water-line*, or rather the line of evaporation." It is necessary to note also that rain-water or soft water acts much more quickly upon lead than hard; but it should not be forgotten that in the soft water the lead is sustained in the water in an *insoluble* condition, and can consequently be easily removed therefrom by filtration; while in the hard water it is *soluble*, and forming therefore a constituent part of the water, it cannot be removed by filtration. Many have doubted the fact, that the lead contaminating soft water can be removed by filtration; but so well authenticated have been the cases in which it has been done, not only by way of experiment, but in daily practice, that there is no longer any doubt of the fact. As to the action, above pointed out, of hard water upon lead so as to render it soluble, Mr. Spencer of Liverpool states, "Both practice and experiment show that air and moisture, when combined, are alone sufficient to oxidise lead, although they do not possess the power of rendering the resulting oxide soluble, *this second action being altogether due to the mineral or organic* substances which the water may happen to contain." And the same high authority states that, "as a rule, most of those salts which give to water its hardness are capable of dissolving the hydrated oxide of lead." The joints of the lead lining of cisterns give way very rapidly under the action of hard water, the oxide being more rapidly produced in consequence of the *voltaic* action induced by the dissimilarity of the metals, the solder (composed of lead and tin), and the lead lining; the superior electrical conductive power of hard water promoting the chemical action. It is worthy of notice that water containing any substance in solution is more rapidly decomposed than when pure—the water being decomposed, carbonated hydrogen given off, and the resulting oxygen combining with the lead; the consequence is, that holes are speedily formed at the bottom of the cistern where such matters have rested. Hence the necessity for taking measures to prevent extraneous matters, as leaves, &c., from gaining admittance to the interior of the cistern.

118. Having thus shown the important action of water upon lead, we proceed to point out the substitutes for it in the lining of cisterns, not deeming it at all necessary to give evidence as to the deleterious action of lead on the health when taken into the system by means of water impregnated with or containing it either in a soluble or insoluble state.

119. By far the cheapest substitute yet introduced for lead lining for cisterns is sheet gutta percha. It is in every way superior to lead—it is more lasting, cheaper in its first cost, cheaper in its application, and incapable of being acted upon by the water, whether hard or soft. The operation of lining the interior of the cistern with the sheet gutta percha is very simple, and may be easily performed by any one possessed of a little patience. The different sheets should overlap each other at least three quarters of an inch, and be made to adhere together closely by means of a hot (flat) iron passed over the joints. A much cheaper method of using the gutta percha, however, is by making it into a thin solution by means of *coal naphtha*—similar to the composition used for putting on shoe-soles—and painting the interior with this. Care should be taken to have the interior very dry; and to form a bond or key between the wood and the gutta percha, a number of small apertures may be made in the wood; the soft solution will go into these small apertures, and a firm hold will thus be obtained.

120. Slate is an admirable substance of which to form cisterns, and is rapidly coming into use. Cisterns might be formed with advantage of iron, lined with the patent glass enamel now so largely introduced for the lining of pipes, tubes, culinary vessels, &c., &c.

121. For rain-water *zinc cisterns* are sometimes used; they are light, cheap, and durable; where substances, however, gain access to the interior so as to induce a galvanic action, holes are speedily formed. An oil or other barrel forms an excellent temporary rain-water cistern; to prevent its speedy

decay, and with a view also to keep the water sweet, and not liable to speedy putridity, the interior should be well *charred*, by burning a few sticks and shavings in the interior.

122. Although water does not act so quickly or deleteriously upon the interior surface of lead pipes, principally from the fact of their being always full, thus preventing the alternate change formerly alluded to (see par. 117), still, by many it is considered advisable that water for domestic purposes should *not* be allowed to come in contact with any substance that may induce a deleterious action. To obtain this desideratum, gutta-percha pipes have been introduced, and with considerable success; they are cheap, durable, and easily repaired when burst, cut or otherwise damaged. The bituminized paper pipes are being rapidly used for the conducting of water; they stand a high pressure, and have no influence in deteriorating the quality of the water.

123. Our readers are doubtless aware of the waste and annoyance caused by the leakage of imperfectly-constructed water-taps. To obviate this many forms have been introduced. We figure one which is in high repute with architects; it is known as Chrimes' water-tap. The drawing in fig. 13*a*, Plate XXXI., represents a form used for "high pressure," in which the valve is loose from the spindle—the valve being opened by the turn of the spindle, but closed by the pressure of the water only after the spindle is relieved from the valve by the turn of the handle. The valve is a brass disc covered with leather, and pressed on to the seat by a screwed spindle working through a stuffing-box. This form of tap is easily repaired, a new leather being quickly put on without disconnecting the cock.

124. In fig. 28, Plate XXXI., we give the section of an underground soft water cistern. In making the excavation, an extra depth should be allowed where soils are disposed to be treacherous, so that a layer of concrete may be placed below the foundation. The diameter of the excavation should also be larger than that of the cistern, so that a space may be left behind the brickwork, into which well-puddled clay may be carefully rammed. The brickwork—of best grey stocks—may be set in mortar, composed of one part of lime to two of clean, sharp, river sand. But if perfect satisfaction is desired, the whole should be set in hydraulic cement. The brickwork should be carried up in 2-feet courses, and the puddling of the clay be well rammed in, then another course carried up and the puddling done, and so on till the point where the springing of the arch commences. The vertical walls may be continued upwards to a level with the crown of the arch, and a man-hole door should be placed there, and the whole covered over with dry ashes. An inlet and overflow pipe are both required. The water is generally withdrawn by means of a pump, which is placed in the scullery, care being taken to have the cistern near enough the scullery that the pump may draw well. Iron pipes are often used to lead the water from the cistern to the pump, but we have never found these satisfactory in practice. The water has a peculiar action in some cases on the iron, and, rusting it rapidly, deteriorates the quality of the water. If bituminized paper or gutta-percha pipes are not used, lead is preferable to iron. Iron pipes are, however, rendered innocent enough by coating their interior with coal tar, the pipes being, during the process, maintained at a high temperature; a species of enamel is thus produced which effectually resists the corroding or chemical action of the water.

125. A few notes on the size of cisterns, &c., for various quantities of water, may here be useful. The average vertical depth of water falling on a roof during any two months may be put down at 7 inches. Take the length of the roof space and multiply it by the breadth, making the quotient in inches; divide the product by 231, which will give the number of gallons for each inch of depth; multiplying this by 7 will give the average rain supply for two months. The contents of a cistern of any proposed dimensions are ascertained as follows:—Take the diameter and depth in inches. Square the diameter, and multiply the product by ·0034, which will give the number of gallons for each inch of depth. Every inch of rain fall gives for every space or surface of roof *ten feet* square, 63 gallons annually; a "square of roofing," of 100 feet, will yield for every inch of annual rain fall, 630 gallons. A roof 30 feet by 40 feet will give, with an annual fall of rain of 3 feet, a daily supply of 63 gallons.

126. In sinking wells for the supply of spring water for suburban villas and rural dwelling-houses where water is not supplied by the towns, a good deal of judgment is required. In places where, in spring-time, the grass assumes most quickly a lively green, water may be safely predicated to be there; and in summer these spots are generally indicated by insects hovering in column over them. In such places water will likely be found at a short distance beneath the level of the ground. The depth will be greater in close tenacious clay, or in sand or gravel. Water will not likely be easily obtained in trap-rock strata. Boggy land, though yielding water readily at a small depth, gives generally a quantity of water of a very poor description—bad in flavour, and muddying and reddening to a remarkable degree when boiled. The veins of sand or gravel which intersect beds of diluvial clay, yield often a remarkably fine quality, and a liberal quantity of water; and from the nature of the soil, pits may be easily dug in it, in which the water collects. Where the depth was not above 8 or 9 feet, we have known an excellent well to be formed by placing earthenware drain-tubes, of 18 inches diameter, in the excavation. Wells, when sunk to a considerable depth, must be lined in their interior either with stone or brick. When "steined" with brick, as the lining is technically termed, a wooden "drum-curb," 4 or 5 feet deep, and of the same diameter as the well, is provided. The curb assumes, when finished, the appearance of a circular ring; the breadth of the ring being equal to the length of a brick, or 9 inches, the internal space affords room for the men to work in. The excavation first made in the earth is equal in depth to the depth of the "drum-curb." In this excavation the "drum-curb" is laid; and as the earth beneath the curb is excavated, it gradually descends. The brickwork is then built on the flat ring of the curb, and as the sinking of this proceeds, the brickwork is laid on till the necessary depth is obtained. The whole excavation is thus lined with brickwork, which is set loosely, the joints having no mortar between them, and each course is so set that it breaks joint with the course below.

127. A few notes on the subject of *filtration of water* may here be useful. And first, as to the appliances connected with this department applicable to cisterns permanently fixed, whether these be used for storing up water supplied on the "intermittent supply system," or for rain-water collected from the roof. Filtering compartments attached to cisterns are of two kinds—that in which the water *ascends* through the filtering media, and that in which it *descends*. To construct one of the first kind, let us suppose the cistern to be 3 feet 6 inches broad, 4 feet 6 inches long, and 5 feet deep. At one end make a compartment or division, 12 inches wide, by means of a partition stretching across the breadth of the cistern. This division must be flush with the upper edge, but must not reach the bottom by 1½ inch. As the depth of the cistern is 5 feet, the depth of the partition will thus be 4 feet 10½ inches. The cistern will thus be divided into two compartments—one of them 3 feet 6 inches long by 3 feet 6 inches broad; the other, 12 inches in breadth by 3 feet 6 inches long; and a communication will exist between the two by an opening 1½ inch wide by 3 feet 6 inches long. In the bottom of the smallest division or compartment place a layer of well-washed

pebbles, or hard round stones, not less than ¾ of an inch in diameter, but not more than 1 inch, or 1¼ inch, or thereabouts. To prevent them from passing from the small to the large compartment, a piece of perforated zinc should be nailed across the opening leading from one division to the other. If round pebbles cannot be obtained, pieces of clean hard-burnt tile or vitrified glass may be used instead. Above this layer place a second of clean gravel; next, a layer of charcoal (peat); a second layer of gravel; and lastly, one of clean sharp *river* (not sea) sand. The foul water to be filtered is delivered to the *large* compartment; it passes through the opening at the bottom of the cistern, and up through the various layers of filtering media, and fills the remaining space of the small compartment, from which it is withdrawn by the usual means. As long as the large compartment is filled, the small compartment will always have a supply of filtered water, the level being the same in both compartments. The water to be filtered may be delivered to the small compartment; and, passing through the filtering media, the large compartment will contain the filtered water. In this case the filtering compartment will be of the second kind, in which the water descends through the filtering media. Where the water to be filtered contains an abundance of extraneous matter of comparatively large bulk, as portions of leaves, decayed vegetable matter, &c., &c., the filtering media may be made as follows:—First, a layer of round pebbles; next, a pretty thick layer of clean, well-washed wool; next, a layer of pebbles, but of smaller dimensions than the first layer. This filtering media may easily be taken out and cleansed. To clean the filtering media of the other methods we have described, all that is necessary is to reverse the action of the current, letting the soiled water from the filter pass away. Where the water is supplied by the high pressure system, filters are attached to the tap, or are placed so as to pass the water near to the scullery sink. A remarkably good form of filter adapted to this system is illustrated in fig. 18, Plate XXXI., being that invented by Ransome of Ipswich, in which the filtering material is composed of his patented silicious stone. In the arrangement illustrated, by means of the two way-cocks, the water may either be passed at once from the cistern without passing through the filter, or may be made to pass through the filter as desired. A very admirable kind of filtering material, adapted for either the high or low pressure systems, is the newly-introduced *solid carbon;* the water to be filtered is forced by pressure or by gravity through a block of this material, which rapidly purifies it. In Plate XXXI., fig. 35, we illustrate a form of filtering cistern, in which *a a* are the walls; *b b* the cistern, divided by a partition *c c*, but which stops short of the bottom at *d*, allowing the water to pass up through the filtering materials; *e* the pipe to supply the water; *f* that to withdraw it when filtered.

127. We now take up the last division of the subject (see par. 97), namely, "On some points connected with the conveniences and fitting-up of houses;" and first of these we refer to is that of "water-closets." The following, from "Minutes of Information on House Drainage, issued by the Board of Health," conveys some useful physiological and constructive information on the subject:—"It is of advantage that the seat should be low—lower than those in common use. The height of the seats of the common privies and water-closets is objectionable on physiological grounds, and the lower seat is also more convenient for children and young persons. In respect to materials, cast-iron pans are found to be objectionable; they oxydise rapidly by the action of wet and air. This bad quality is attempted to be remedied by glazing; but if there be any part of the glazing defective, or as soon as it becomes so, the pan is rapidly destroyed. The stoneware pottery soil-pans are free from these objections, and they are not liable to injury from frost. Where parties choose, either wood or cloth might be put over the seat, and it might have a double wooden cover on the principle of a seat in a frame to be lifted, and vessels emptied into the sink or trap without wetting the seat. It is desirable to dispense with wood-work as much as possible, not only on account of expense, but also because it is absorbent of filth and gases, and not so readily cleansed as earthenware. For cottages not having in-door convenience for privacy, this apparatus can be easily adapted to the present privy building, so as to abolish the offensive and disgusting state of such places, described in every report presented to the Board, as among the most injurious and demoralising features of provincial towns. It is most important also that the apparatus should occupy but little space, so that it may be conveniently introduced amidst old and confined habitations. Arrangements should be made for cleansing the improved privies, urinals, and sinks in lodging-houses, by means of jets of water instead of the broom. For this mode of rapid and complete cleansing, earthenware will be highly convenient. . . . . Whilst providing this soil-pan apparatus, provision for the covering of it, that is to say, for 'the privy,' properly so called, must, with respect to many neighbourhoods, be considered, as to secure the means of privacy and decency. In suburban districts the cesspool and the privy are, in the fourth-rate houses, often placed at the end of gardens. When the cesspool is filled up, and the soil-pan apparatus substituted, one reason of the site of the privy being so far distant from the house will be obviated. The expense of carrying separate water-pipes and separate drain or discharge-pipes to so distant a site renders it ineligible. Privacy, but above all, the convenience of the feeble and the sick, especially in inclement weather, require that the site, if not within the house, should be brought near to it. It is only when the house and main drainage is completely amended, and then with care, as recommended, that the apparatus should be brought within the house. The water-closet being generally placed at the back part of the premises, it is suggested for the consideration of owners, whether they could not in most cases form the privies on the outside of the back part of the house, with a communication through the back wall from the landing of the staircase or elsewhere." For houses of the better class a great variety of apparatus has been introduced of late years, and it is difficult to say which form is the most highly thought of. As a rule, it may be held that the more simple the apparatus, and the freer it is from complicated mechanism, the better. By far the best form, to our way of thinking, is that known as "Jenning's India-rubber Tube Closet." It is noiseless in its action; when closed acts as a perfect effluvia trap; and can scarcely ever get out of order. The only objection to it is that the tube is apt to be cut by articles of broken crockery or glass, which careless and deceiving servants are apt to throw down the closet so as to put out of sight the evidence of their carelessness. Against causes of this kind the apparatus cannot—as, indeed, no apparatus can—be said to be secure. Nevertheless, this form of closet is by far the best we know of. It consists of an adaptation of an india-rubber (vulcanized) tube attached to the lower edge of the pan-basin; this tube is embraced by a clip, which, when acted on by a weighted lever, grips or compresses the tube, closing it perfectly air and water tight. This lever is in action when the closet is not in use; but when in use, it is raised by a handle, which releases the clip, enabling the tube to expand, and at the same time opens a valve, which allows the water to rush in and flush the cistern. Fig. 36, Plate XXXI., illustrates another and simpler form of closet introduced by the same manufacturer; this is distinguished by an absence of all wires, cranks, &c., the basin, the valve-seat, and the trap, being all of earthenware. There is one form of water-closet apparatus often adapted to

rural or suburban houses, where a special cistern is used to catch rain-water from the roof for the purpose of flushing the closet, which is placed immediately below the cistern. A pipe leads direct from the cistern bottom to the pan of the closet, and is provided with a conical valve-seat at the point where it enters the cistern. A valve works within this seat, and is lifted up perpendicularly out of or let into its seat by a wire attached to the end of a lever, the other end of which is actuated by a wire passing down to, and connected with, the lever, which, by means of the ordinary handle at the seat, lifts the trap of the pan. We mention this form of closet to warn our readers from fitting it up. The valve is always liable to be kept from passing fairly into its seat by leaves or other obstructions, so that water is often constantly leaking through it; the wire is apt also to get out of order, and as the pipe must get filled, and the water must run down it for some seconds to gain sufficient momentum, the operation of flushing the pan is a tedious one.

129. Amongst the useful appliances in a house is the *washing-stone* in the scullery. The best example of this is to be met with in the "slop-stone" of a Lancashire scullery, the worst, in what is called the "sink" of a Scottish kitchen. The slop-stone is made of stone, is of large dimensions, and is *shallow;* the sink is of small dimensions, and deep, the result of which is, that while the former is easily kept clean, the latter is not so, and is, indeed, from its depth, a receptacle—too often so — for all sorts of disgusting and nameless filth, and well deserves the name of a "sink." The slop-stone should have plenty of light thrown upon it, and the hollowed-out part should not be more than $1\frac{1}{2}$ inch in depth, and have no right angles at any part of it, but the corners neatly rounded, as also the edges, so that no angles be allowed which harbour dirt. A margin of at least 3 inches should be left all round, but at one end a large flat space, as *a*, fig. 39, Plate XXXI., should be left, at least 2 feet long, on which to place utensils. The slop-stone should rest upon bull-nosed brick pillars *c c c*, a space being left at *d* in which to put away the kettle, filter, or the like. To say so much about so simple a matter as this may appear to some to involve a loss of space, but nothing that is useful, or which adds to the comfort of the inhabitants of a house, or aids the labours of its servants, can be said to be unimportant. Indeed, it is upon the little conveniences of a house that much of its social completeness depends.

130. The *dust draught* is another of these little things which add greatly to the comfort of a house. This is an appliance which may be said to be confined almost exclusively to the houses of one district in England, but it is one which nevertheless deserves to be introduced into every house, the inhabitants of which desire to get rid of—as who does not?—a source of annoyance in the dust which enters and flies about a room every time the fire is stirred, or the hearth swept up. We illustrate this appliance in fig. 40, Plate XXXI., in which *a* is the grate, *b* the flue, *c* the back wall; in this is a flue *d′ d*, opening at the lower end *d* into the space below the grate, and at the other end *d′* into the chimney flue. The strong draught created by the action of the chimney-flue *b*, causes a constant current to be maintained in the flue *d d′* so strong, that all dust falling from the grate, or made on the hearth, is instantly swept up and passed into the flue *b*. Cognate to this appliance, allusion may be made here to the "*ash grid and shoot*," supplied to kitchens under which there is a cellar. This is a great convenience, at once enabling the thrifty housewife or careful servant to separate the cinders—for consumption on the fire—from the ashes, and to pass the latter to the cellar below, from whence they can be taken at intervals as required. It simply consists of a flue, *a a*, fig. 41, Plate XXXI., passing down from an opening made in the hearth, below the kitchen grate, to the cellar apartment below. The opening below the grate is covered with a grating, the longitudinal openings of which are at right angles to the length of the hearth. By means of the edge of the shovel, the ashes can easily be separated from the cinders, the former passing down the flue *a a*, while the cinders are left on the grid to be removed for careful consumption. (For notes upon fire-grates and cooking-ranges, see Essay Eleventh.) We have thus gone over a few of the points connected with the arrangement, construction, and conveniences of houses, and we have to regret that space has not permitted us to exhaust all the departments which have been discussed. We hope, however, to be able in the undernoted work* to go more fully into the whole subject, and to touch upon points which our present space, and, indeed, the scope of the present Essay, has prevented us from doing.

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* The Grammar of House Planning and Conveniences. Profusely Illustrated, 8vo. A. Fullarton & Co., Edinburgh and London.

ON STRUCTURAL DESIGN AND DECORATION.

1. THERE is, perhaps, no subject which has been so much discussed, and about which so little decided and definite has been agreed upon, as that which forms the basis of the present Essay. Architecture, termed by one—himself a fine expositor of its works—"the noblest and grandest of all the arts," in place of displaying an example of an art having thoroughly and well defined the principles which dictate, or should dictate, its practice, offers, on the contrary, one in which these are uncertain, confused, and often contradictory. One authority expounds a belief in certain principles, or what he deems to be such, on which the vitality and the truth of the art depends, which, in turn, are denounced by another as calculated only to debase and degrade it. The very terms, indeed, which are used in the discussion are by no means received as definite in meaning—one drawing one class, another a different class of ideas from the same words. To such an extent does this prevail, that the very name which defines the art and sets it apart from others has yet no universally acknowledged meaning, its definition varying almost with the number of its expositors, so that one defines *architecture* to be what another declares it is not. Amidst all this diversity and contrariety of opinion, therefore, it would seem to be a hopeless, and, as some doubtless think, a most thankless task to endeavour to elucidate principles which will be received as calculated to refine and enlarge the domain of architectural practice. Still, there are certain principles which, once stated, cannot well be denied; so that, however little these may influence the practice of those who may consider them, they cannot, at all events, be otherwise received by them than as true. And so, as an immoral man may believe in the truth of principles which, in his daily life, he despises and defies; yet there is more hope of his reform than of him who, while immoral, has a thorough unbelief in the principles of morality, so in like manner lies the hope of a brighter future for architecture, that certain principles, being received as true, may yet tinge the practice of those who, while they do not warmly believe in, yet cannot confute or deny them. We have said that it is apparently a hopeless task to expound the principles of an art about which, as we have seen, so much diversity and contrariety of opinion exists; and certainly it would be so within the limits of an Essay like the present—limits which are of necessity narrow in the extreme. We cannot, therefore, propose to do more than give a rapid *resumé* of the best thoughts of the best writers of the day on this important subject, adding here and there such notions of our own as may be likely to further elucidate the opinions of others. To have no higher or more original aim than this, for an Essay, may not be ambitious; enough for us, and we hope for our readers, that it aspires to be useful.

2. We have already said that no definition of the term Architecture has as yet been accepted universally, and yet it is obvious that the first thing to decide upon in discussing a science or an art is to know what are its aims, its objects, and its duties. And that this is very important may be instantly recognized when we consider that building—*i. e., construction*—is by many deemed to be a thing altogether distinct from its *architecture*, so much so, that to use a stereotyped form of expression, a building is raised without "any attempt at architecture." It is clear, then, that where such an opinion prevails, the attempts at *architecture* will be few in number, and where attempted, miserably meagre in beauty and effectiveness. But here, at the very outset, we are met by these inquiries—What is Architecture? and, What constitutes its beauty? A structure may be well built—that is, strongly built—and it may be conveniently—that is, fitly—built; yet that structure may have no claims to be considered as an example of pure architecture; something still remains to be added to it to raise it to this dignity. To the attributes named above it must possess another, namely, that which pleases the eye and gratifies the mind of the spectator, or, in other words, it must possess beauty. Here, then, we have, according to one writer, the three principles of a true architecture:—First, *fitness for the purpose for which the building is designed*—that is, that your building shall minister to the necessities of those for whom it is built, so that while a man asks a theatre you do not give him a building in which actors cannot be seen nor their speeches heard; secondly, *strength or stability*, so that it will not only look like a building calculated to stand, but that it shall in reality be capable of doing so; and thirdly, *beauty*, so that while we look at, we shall be pleased with it, and see something in it which will gratify the intellect. This definition of the term architecture, or rather this exposition of its aims and objects, is very similar to another which has been put forth by a well-known writer, and which may be gathered from his statement of what he considered were the principles by which the "true styles" of a bygone day were, and by the adoption of which they may again be, produced. "The architect," he says, "had only to consider—First, how he could contrive the most *convenient and appropriate* building; secondly, how he could arrange this so as to be *most ornamental* with the least possible sacrifice of convenience; and thirdly, how he could accentuate and *ornament his construction* so as to be most obvious and elegant." From this may be at once deduced those principles which the same writer defines as those dictating the practice of true design in architecture, and which he classifies under four heads, namely—(1), convenience in arrangement; (2), economy in construction; (3), ornamental arrangement; and (4), ornamental construction. We have, then, here explained what are the elements of a true architecture, but it is difficult to say which of these elements is most important; at all events it may be disputed. "But," to quote the words of an able reviewer, "there can be no doubt which element arises from the most deep and complex sources, and goes furthest into human nature. The wants which building supplies are universal, and comparatively alike everywhere. But the features which raise building to a fine art must be sought in the depths of the character of each nation. To unfold this, if it were possible, would be the most interesting portion of

the History of Architecture. That which gave the Ionic capital to Thebes, the Doric to Athens—that which gave massiveness to the Roman style, aspiring grace and floral delicacy to the Gothic, lies in the very heart of the respective races. The ornament of the 'true styles' expresses the religion and poetry of the nation, and is part of that spirit, whatever it may be, which displayed itself in the mythology of Egypt and of Hellas, which found another mode of expression in Homer and Sophocles, in the 'Nibelungen,' the 'Romance of the Rose,' and the 'Divina Commedia.' We are here, in a word, within the realms of the divinest of human gifts—the creative imagination."

3. Although the elements which we have named are generally, we may say universally, received as distinguishing the art of pure architecture, still the same unanimity of opinion does not exist as to the mode by which they are to be attained; this, to be sure, applies with less force to the elements of convenience and strength, but assuredly is particularly applicable to the element of beauty, or that by which the eye and the mind of the spectator of the structure is pleased and gratified; for on this point the widest diversity of opinion exists, and in connection with it the most contradictory of theories have been expended. Let us endeavour, out of this chaos of opinion, to educe some harmoniousness, so that if we be not able to expound fully all the principles upon which beauty in building is obtained, we may be able at least to suggest matter for thought and study.

4. And here, at the outset, we must point out the importance, first, of thorough earnestness of purpose in designing; and secondly, of a persistent attempt to give the force of truth to the design. It is but trite to say that no good thing was ever brought about but by the exercise of earnestness of purpose; and yet this truth, trite as it is, has been wofully neglected in the practice of architecture. With an earnestness of purpose on the part of the designer, a design may be faulty; but whatever it be, it will not be meaningless and tame—it will display, at all events, the evidence of *mind* laid out on it; and where this evidence is, we defy a building to be poor and paltry in its conception. Then again, as to truth of expression in a building; where this is wanting all true vitality is wanting. Let the designer ever bear in mind this, as stated by one of our finest expositors of architectural art, "Seek not to seem what you would be, but to be what you would seem," a sentence which, he states—and, as we think, truly—he suspects to "contain nearly the whole theory of art."

5. Following, for convenience of arrangement—if not on account of its being the best—the definition of the aims and objects of architecture, as given at the end of the second paragraph, we shall glance briefly at the characteristics of its various divisions. On the first of these—namely, "*convenience in arrangement*"—little need here be said, the importance of this being obvious enough, and from its having been fully discussed in another Essay of this work.

6. Of the second element of architecture, "*economy in construction*," it may be said that in this department constructive science is of the utmost possible importance. The economy of material, which is brought about by the exercise of scientific skill, is, in its lightness, and yet strength, a pleasing contrast to that lavish expenditure which, while it crushes, confuses. But there is a principle of taste connected with the economy in construction which must not here be overlooked, and that is, the more you *economise material*, and the more you *lavish thought* upon a structure, the higher in rank you place it. A well-known writer calls this a "unique principle" and "a noble imitation of nature," and which he thus expresses:—"The most lavish expenditure of labour (or at least of thought) seems to have been considered no waste if effecting the smallest saving of material." This, he states, was the characteristic of the Gothic architecture at its best period, and its whole "decorative system consisted in removing superfluous matter not conducive to strength." Where this element of architecture, then—"economy in construction"—is thus attempted earnestly to be secured by the designer, this alone will give to his completed structure that which, if it delights not the eye, will please the mind.

7. On the third element (see end of par. 2), namely, "*ornamental arrangement*," more will have to be said, as this is, perhaps, the first of those elements which belong to what has been called architecture proper. Ornamental arrangement has been called, and called truly, the "foundation of all good architectural design," and by the same writer is defined to be "the arranging the various parts of a building, or a group of buildings, so as to be in harmonious proportion one to another, and so that each may aid every other part in producing the effect desired." The mode in which this part of an architectural design is carried out stamps, indeed, the genius or otherwise of the designer. Some utterly fail in this, and attempt to conceal the defects of their design by overloading it with ornament, giving greater prominence to the fourth element of design, namely, "ornamented construction." By these the truth may be brought to mind with advantage, that vulgarity is only rendered the more vulgar by excess of ornament. This attempt—too often made now-a-days—to conceal inherent defects of ornamental arrangement, has been well characterized by an able writer on architecture as "rudeness," or that quality opposite to the courtesy which all buildings should possess—a courtesy which displays itself in consideration for the feelings of the spectator, so that he shall be gratified with it, beholding it with the consciousness that the owner has thoughts for others than himself merely; for if we see a building which possesses no other claim to notice than that it is richly or unsparingly decorated, we know at once that the idea of the owner is that he shall enforce admiration, or at least notice, by a display of his wealth merely, which feeling is in all things and in all ways essentially vulgar. The same writer who thus characterizes such attempts as "rudeness," has some highly suggestive remarks on the importance of courteous design, or, in other words, "ornamental arrangement," which we shall do the reader a service by epitomizing here. He points out how Palladio and others have shown that in plain buildings, strictly so called, positive beauty has been created without the introduction of any decoration, but simply by "a studious collation of whatever will display design, order, and congruity, in the relative dimensions and arrangement of the necessary or useful features." He then goes on to illustrate this by supposing the mode of carrying out a design in two different ways, the one by a mere constructor, who would make two features of the building—as two string courses—precisely the same; the "true architect" introduces skilfully an inequality in them, because he knows he thus obtains a beauty by "variety, subordination, and contrast of parts." So in like manner, while an ordinary builder would "make certain divisions in the height or breadth of the building equal or varying according to no definite law," the true architect would, by "carefully distinguishing between what convenience *required* and what it (or rather his first idea of it) suggested," would adjust all the dimensions and parts, so that the building would exhibit a "variety, a contrast, a law of variation, a gradation, a progression, a proportion;" in short, all the indications of *mind* having been put forth in the design. Few, he remarks, have any conception how beautiful a building may thus be made without any ornament at all, meaning by the term ornament, not merely "carvings or forms drawn from nature," but "even mouldings, or any of what are called architectural features, *i. e.*, features unnecessary to the construction." And he points out what is, perhaps, too

seldom thought of, that it is more in the plain or undecorated buildings than in the richly decorated ones that the hand or the mind of the true architect is shown, so that, paraphrasing Michael Angelo's aphorism, "Learn to sketch before you finish," good, nay, perhaps the best advice which can be given to a young architect, is, "learn to produce beauty in bricks and rubble before you attempt it in friezes and traceries." Ornamental arrangement, then, when carefully studied, is the foundation of all good architecture; and it not only secures beauty in the building, but economy in the construction, which last consideration is not the least important in these days of contracts and cheap work. For, to quote the words of another authority on architectural design, "good construction, beautiful outlines, beautiful forms to their openings, this is art, this is all design, all this is ornament, and very little carved or moulded, and no cast ornaments of iron or other material will be needed to set off a building where all is graceful in form." If we wish most thoroughly to understand what a power is given to the architect by a careful study of ornamental arrangement, we must devote some time to the patient examination of the great works of the Gothic architects. In their works, says an able writer, we see how "a building may be so ornamentally arranged as to produce the best possible architectural effect without ornament, or with only the smallest amount of applied decoration. * * Take, for instance, Salisbury cathedral; the windows are without mullions, the buttresses without pinnacles, and with very few mouldings, while the walls are singularly plain, yet with all this, the nave, the two transepts, and the choir, are so pleasingly arranged as to produce the best effect; and if you come to look closely into it you will find that the problem being given of producing a vaulted hall of a certain height, to cover a given area of floor space, it would be hardly possible to do it at less expense. The buttresses, for instance, on which the external effect mainly depends, are the most economical way of disposing of the quantity of materials required for the purpose, and the intersecting transepts the cheapest conceivable mode of roofing a great area of floor space, and at the same time of making a small building look large internally as well as externally. The Italian architects, who neglected these expedients, used, in consequence, three or four times the quantity of material which the Gothic architects employed. In St. Paul's, for instance, one of the most mechanically perfect of modern buildings, the area of the solids, as compared with the voids, is 1 to 6; St. Peter's as 1 to 4, St. Isaac's and other churches about the same; while at Salisbury, and in most early Mediæval buildings, it is as 1 to 8, and in later Gothic buildings, it generally may be quoted as 1 in 10, and in some in even a lower proportion than that. Or, to take another example, I have here a section of Westminster Abbey, showing the buttresses on the south side of the nave: nothing can be more purely mechanical than they are, but nothing can at the same time be better adapted to resist the thrust of the vaults of the aisles and nave, which, owing to the interposition of the cloister, they could not approach. A modern architect would probably have built a plain wall at right angles to the thrust, and sloping slightly inwards, have met the difficulties of the case. In so far as expense of execution is concerned, the Mediæval plan may be the most so: to cut the stone of each arch into voussoirs and to put a moulding under each flying buttress would, probably, cost from 5 to 10 per cent. more than to build a plain wall, the amount of materials and the height being the same in both cases; but to do the same amount of duty the wall in this instance would require at least a third more material, because its mass would be near its base, where there was no work to do, so that the ultimate expense would probably be greater. The real objection, architecturally, to the modern system, is that the wall would be a hideous deformity, the buttress a thing of beauty, because it is thoughtful and truthful."

8. But, however carefully ornamental arrangement has been studied, and however successfully its attainment has been secured, the design cannot be said to have arrived at the condition of an example of pure architecture till the requirements of the fourth element of design are met, namely, "*ornamented construction*," (see end of par. 2.) But ornament, where applied, must, as we have already observed, be applied as an accessory, as an addition, not as an essential, its office being not primary but secondary; and so to bring out as it were the expression of the design, and add to it the lighter, the elegant, and more pleasing graces which mere arrangement, however ornamental, (see last par.,) will not alone give. But the ornament which is added to a building must be in keeping with the character of the design, calculated to set it off, or to use the expression of an authority, "to accentuate the constructive details," and enable the "whole story" of the building to be "told in an agreeable manner." To this end ornament must show evidence of mind being given to its design and to its application. It is the easiest thing in the world to stick on in endless variety and vulgar profusion ornament on any building; but this is to display the mercenary extravagance of the modeller or the seller of ornaments, or to please the vanity of a vulgar owner, not to show the mind and the talents of the true architect. And it is perhaps one of the most painful evidences which we nationally can show of the depth of degradation to which much of our architecture —if indeed it be not, as we think it is, a degradation of the name so to use it here—has fallen, the extravagant display of unmeaning ornament which is stuck over the fronts of many of its modern buildings. Ornament, to be good, must be truthful, a truism wofully neglected in our day; and where falseness is obtained, be it at what expense it may, it is never, and can never be, any thing than base and unsatisfying. Examine the works of the true styles of architecture, the Classical and the Gothic, and you will find all their ornament based upon truth—not an ornament is used but is appropriate to, or, as it were, caused by the mechanical necessities of the part to which it is applied. This truth is, perhaps, more strikingly exemplified in the pure examples of Gothic than in those of Classic architecture; for, as an authority remarks, "the elements of construction in classic architecture are so simple that they do not afford striking illustration of the principles of ornamental constructive value;" nevertheless, "every ornament is appropriate to the use of the part to which it is applied, and is elegant in itself, so that all the requisites of good architecture are satisfied, and the result has commanded the approval of all succeeding generations." But construction in Gothic architecture being more complicated, we have more numerous exemplifications in it of how ornament springs out of, as it were, the constructive necessity, seeming to aid, while, in reality, it adorns and graces it. The "vaulting shaft," the "vault ribs," the "windows with their mullions, the buttresses with their pinnacles, the towers and steeples, all obey the same laws, all are based on mechanical exigencies, but these are made gradually to yield a part at least of their demands to ornamental arrangement." How opposed to all this truthful mode of giving expression to a building by ornament, is the modern mode of applying it. Brackets which bear nothing, friezes and cornices purposeless, mouldings meaningless. Let us sum up this paragraph on "ornamental construction," in the suggestive words of one who has thought deeply on the subject, and to whom the architectural world is so much indebted for his inquiries and investigation into it. "If one ornament is used, where under no circumstances it could have been useful, its employment is wrong, and if executed in any material which could not con-

structively be employed for that purpose, it is specially offensive. In a few words, the best architectural ornament is that which expresses the purpose and the construction of the building, or of that part of the building to which it is applied; and it approaches perfection in the ratio in which, besides its power of constructive expression, it is elegant in itself, and pleasing to contemplate irrespective of its architectural position. * * The circumstance that generally leads modern architects into extravagance is, that, instead of truth in construction and beauty of form, they attempt to disguise their buildings in either Classic or mediæval costume; and the moment they attempt this they plunge into incongruities, from which they can only extricate themselves by means of money; and by hiding by means of ornament their want of thought, and thus hoping to distract attention from the falsehood they are perpetrating."

9. "*Truth in construction*," "*beauty of form*," (see last sentence of par. 8,) how are these to be attained? We should probably best answer this important question, by giving a resumé of opinions of various authorities as to what constitutes the one, and how the other is to be obtained. And first, as to "constructive truth." The space at our disposal compels us to be very brief indeed in our remarks under this head; but if we can manage within its bounds to give the reader a fair notion of what Mr. G. L. Garbett, in his work on "The Principles of Design in Architecture," (Virtue, Brothers, & Co., London, 2s.,) has said upon it, we shall be making good use of our space. "Constructive truth," says Mr. Garbett, "requires that a building shall never appear to be constructed on different statical principles from those really employed in its construction." What *is* constructive truth may be learned from what it is *not*—as exemplified in modern Gothic, which Mr. Garbett boldly, yet truly, characterizes as a "constructive falsehood," inasmuch as while true Gothic had its peculiarities created by the practice of "constructing within buildings a vaulted ceiling of stone," and were solely adapted to such; modern Gothic applied to a building not so constructed must be either meaningless—the forms being copied without motive,—or must appear—if the forms are correctly copied—to have a "vaulted ceiling—which it has not;" and in either case the whole must be a lie from the foundation to the finials. Mr. Garbett very lucidly explains the constructive principles of the two true styles of architecture, namely, the Classical and the Gothic—the former being an example of what is called "cross strain"—the latter of "compression." The first Mr. Garbett also calls the method of "vertical pressure," the whole of the pressures acting downwards, so that the "continuous joints or beds throughout the structure are made *horizontal*, and all the interrupted joints vertical." In the Classic architecture all openings are covered by the beam or lintel laid across them, and resting at each end on the "flat tops" of the columns. In pure Classic architecture oblique pressure is never exemplified. Mr. Garbett thus further explains the peculiarities of this style—"up to the roof we find all principal numbers and lines horizontal, and all secondary ones vertical—a consequence of constructive truth; the vertical pressure requiring all continuous joints to be horizontal, and all discontinuous ones vertical. The truth also required the continuation of the cornice horizontally across the ends, (though not there necessary to throw off the wet,) because the two inclined cornices above would have given the expression of oblique pressure, unless tied together into one triangle by this feature. By this means the construction of the roof, though not possible to be displayed, was *truly indicated* externally. Moreover, a support was afforded for the glorious ornaments in the pediments which gave life to the whole." Rickman has shown, that in the pure Greek all the "vertical lines are stopped by the first horizontal one they meet; while the horizontal continue (generally without a bend) from corner to corner of the building"—the horizontal lines in the Greek are, therefore, unbroken. So much for the peculiarities of one of the two pure styles, the Grecian or Classic. Let us glance as briefly at those of the second, namely, the Gothic. In the Gothic, as Mr. Garbett very clearly points out, the materials employed are so arranged that they are visibly subject to "the forces of compression alone"—all cross strain being avoided; the joints not being horizontal, "but inclined in various directions." While in the Greek style all openings were covered by flat lintels or beams; in the Gothic they were covered by the arch and the "oblique pressures thus occasioned were transmitted to the ground by masses of materials called buttresses or abutments." The "arch or vault work," to quote the same writer, being "the fundamental principle of the Gothic system." While in the Greek style all the vertical lines were stopped by the first horizontal line they met, in the Gothic all horizontal lines meeting a vertical are either stopped there or are made to change their direction, the vertical line maintaining its original direction unaltered. In the Greek style the horizontal lines remain unbroken, in the Gothic they are "frequently broken." These distinctions as to the lines of the two pure styles were first pointed out by Mr. Rickman. Let us sum up, in the words of Mr. Garbett, the contrastive peculiarities of the two styles. "In the pure Greek an arch was inadmissible; in the pure Gothic, a lintel or beam is equally inadmissible. In imitative Greek all arches have to be disguised as beams; in imitative Gothic all beams had to be disguised as arches. In the former the props required to confine the arches must be concealed or disguised; in the latter props must appear whether they are wanted or not. * * * Lastly, looking at the general character, the expression of the Greek temple is that of majestic *repose;* that of the Gothic is aspiring *flight*, or, at least, *growth*."

10. But we have still to point out another characteristic of the two true styles, and that also which should distinguish all buildings, that is, "constructive unity." This is, as the authority we have above quoted remarks, "a principle no less important than any other unity, and bears an especial analogy to *unity of style*, being, in fact, the same thing in construction as the latter in decoration." Constructive unity, therefore, demands what, in fact, the words import, a uniformity in the principle of construction, just as in the decoration of a building there should be a uniformity of ornament. So that the building shall not, in its features of construction, display in one part the characteristic peculiarities of one style, as the Gothic, and in another part those of another, as the Greek. Therefore, as a corollary from all this, Mr. Garbett, while adverting to the copying of the two old styles, Greek and Gothic, in modern buildings, says:—"If they are worth copying at all, they are worth copying completely; and this can never be done but by copying their *construction* as well as their decoration. If modern habits or means will not permit this, they will not permit the old style. Count the cost, therefore. If you want to imitate the archless style, your building must be archless or a huge lie. If you imitate the beamless, it must be beamless; and every unvaulted building, ancient or modern, that apes this style, is a motiveless and unmeaning sham." So much, then, for the principles of constructive truth and constructive unity, which must be duly considered and exemplified in every structure, the designer of which is ambitious for it to be considered as a specimen of "pure architecture." After what we have said the reader will be able to draw his own conclusions as to the way in which he is to apply these principles to any given case. He may deem them unimportant, and as not applicable to the structural necessities of modern times; and may, therefore, conceive that a building in which the features

of all styles are mixed up may better suit his own notions or those of his clients; but of this he may rest assured, that however successful he may be in giving to his piebald building the characteristics which please the eye or tickle the vanity of the uninitiated, he will not succeed in attaining a "design" which will, to the educated, possess the attribute of architectural truth.

11. Having glanced at the important point of constructive truth, which is necessary to be attended to in creating buildings architecturally pure, let us now do the same office for the next important point, "*beauty of form*" (see beginning of par. 9). And here the question at once demands some answer, however brief, what is meant by the term beauty? To answer this fully would take a volume, and after all, however satisfactory we might deem the matter of it to be, the probability is that we would please few with our definition, probably none; for there is, perhaps, no subject which has received so much discussion as this of "beauty," and what constitutes it, whether it is purely sensual or purely intellectual, or a mixture of both, or if the latter is true, where the one begins and the other ends. Without, then, attempting to give here an elaborate theory of the "beautiful"—which, indeed, both the scope and space of our Essay forbid—it will serve our purpose sufficiently if we present a few opinions of others on the subject. In Mr. Burnell's paper on "The Application of the Science of the Beautiful to the Common Details of Buildings," the following is given, which, upon the whole, although not agreeing with all which this authority puts forward in support of it, many will take to be a fairly accurate definition of the term beauty, or of the truths it involves as applied to architecture:—"Beauty I consider," says Mr. Burnell, "to be an objective quality, inherent in certain bodies, which enables them to produce in our minds the sensation that the external form of those bodies or things corresponds in an agreeable manner with the idea we have been able to assign to them. It is a quality producing sensation, mainly independent of ourselves, and essentially phenomenal, that is to say, that the external forms of bodies produce the harmony and proportions which induce us to consider that they are in accord with the ideal perfection they are intended to typify, and that physical beauty must be visible to the eye. It is in no wise connected with utility; for many useful things, such as the vital organs of the human body, are, at first sight, essentially repulsive, and as being so, cannot be called beautiful; whilst, on the other hand, the plumage of birds, or the form and colour of plants, frequently strike us as being remarkably beautiful, even though they have no necessary connection with the discharge of the vital functions of the existences to which they belong. But if beauty be thus to some extent independent of ourselves, its perception can only take place amongst thinking and intelligent beings; and just precisely as we cultivate the faculties which enabled us to distinguish the mutual relations of the forms and ideas we consider, will we be able to distinguish the beauty which they possess. Beauty does not exist for the brute creation; and amongst human beings the keenness of the perception of beauty will vary with the circumstances which surround them, and which are able to influence their modes of thought. Education, in fact, increases in man the faculty of receiving pleasure from beautiful objects, and thus it happens that opinions vary with respect to degrees and kinds of beauty; but the attributes of the things or bodies under consideration, which give rise to the sensation of the existence of beauty in them, are parts of them, and are by no means conferred by the operations of the observer's intellect. Beauty is objective, not subjective; we feel it, we do not confer it by any act of our own minds; and objects would be beautiful if their external forms corresponded with their idea, even if there were no one to perceive the relation." Mr. Burnell illustrates this theory of beauty by pointing out, in somewhat lengthy detail—but to which we can only here briefly refer—the "gradations" which usually prevail in the "several divisions of nature" around us, as in the forms of the higher crystallization of inorganic substances, in the form and colour of the vegetable world, in the beauty of the plant and of the flower, in the fine forms and colour of the lower animals, and in the higher and wider expression which life gives to them, and at last, in the human figure divine, where "both form and colour become subordinate as causes of beauty to the expression of the intellectual faculties." The same gradation, "in the relative degrees of beauty," Mr. Burnell points out, "prevail in the arts, and they are able to satisfy our minds the most completely when they suggest the notion, that by them are expressed the relations between the external forms of the objects represented and an ideal conception of what it should be." This theory of the beautiful, although much opposed to other theories which have been promulgated, is evidently that which coincides with what we here venture to say is the popular one, and which at once accounts for the fact, that there is apparently no standard of beauty accepted by all, but that, on the contrary, that which is deemed beautiful by one is not so deemed by another spectator, and this, arising from the fact that the "ideal perfection they are intended to typify"—to quote the words of Mr. Burnell—varies with various minds, some seeing in a certain form a "type" which is totally different from that seen by another. This theory also explains, if it is not in some respects the same as that of Alison, which maintains that beauty is dependent altogether upon the *association of ideas* we have in reference to them. How different forms "seem to be connected in our minds with very different associations, or to be expressive of very different qualities," may be gathered from the remarks of Alison, in his celebrated Essay "On Taste," which are worthy of perusal, as bearing upon the part of the subject now under discussion. From these it will be seen that Alison maintains that "winding or curvilinear forms" convey the *association* of "weakness, fragility, or delicacy;" strength and power by angularity; the first of "volition and ease," the second of "force and constraint." We shall again refer to the points so finely stated by Alison in further explaining the effect of mere form as an element of beauty in architecture; but meanwhile we proceed to notice that this theory of association forbids us to believe that buildings, or their forms, have any "abstract expression," to quote the words of an able authority, "apart from association with natural objects." The same authority points out how certain objects—and we have ourselves above alluded to the fact as bearing upon what we have called the popular theory of beauty—which to one mind convey certain associations totally fail to convey the same—or indeed any other—association to another person; and draws attention to the fact that this "influence of association extends into all the arts, to the great detriment of the higher ones, especially architecture;" but while at the same time saying this, he does not say that the "time-hallowed associations," for instance, which we attach to certain architectural embodiments are to be broken through, only that it is essential that the "acquired" expression of a building—that is, the "association" expression shall not be mistaken for its real or "natural" expression—that is, we ought to distinguish carefully between associations which are accidental and those which are essential. It is very difficult, however, after all, for any one to divest himself of peculiar or particular associations in viewing forms. In the case of natural forms, both organic or inorganic, we almost intuitively do this—as so well pointed out by Alison—but in the case of the artificial productions of man the power of association is not so fully developed, and we frequently come to their study or investigation with no preconceived associations, on the contrary we come to them ready

to receive "what tale they have to tell us." This then leads us to consider the connexion that subsists between the purposes for which buildings may have been designed, and the beauty of their form or of the ornaments by which they are decorated. Now, while it is true that no building can give an accurately defined expression of its destination—architecture not being a phonetic art—nevertheless, as finely pointed out by an able authority, it possesses the power of certain expressions, "whether grave or festive, meek or ostentatious, awful or joyful, majestic, reposing, agitated or aspiring. . . Otherwise if there be no differences of expression in architecture, then it is no fine art, but a trifle beneath the notice of an educated man, and which must soon find its level by sinking into the hands of mere constructors and decorators." Again, says Mr. Burnell, "all the parts of a building may be pleasant in themselves; they may possess a very great degree of the beauty of inorganic nature; they may be regular, perfect, symmetrical, or even picturesquely irregular; they may possess the charm of colour and tone; yet if they do not combine to form a whole which should be able to convey the notion of a perfect embodiment of the ideal of the purpose they are destined to fulfil, they cannot produce in us the sensation of beauty. The eye may be pleased for a time, the mind cannot be satisfied by any such incomplete expression of its own requirements." In other words, the building must possess the attributes of consistency.

12. From what we have given in the last paragraph, the reader will, in all probability, have come to the conclusion, that beauty is a very difficult thing to define; and that much of its perception depends upon the individual himself—the "association he has in his mind with reference to certain forms," according to Alison; or upon the "ideal" which, according to Burnell, he has raised up. It would seem, therefore, that it would be a useless task to attempt to describe what really constitutes "beauty of form," (see beginning of par. 9.) Yet there are certain "canons," or principles upon which, if they are not perfect, yet a degree of comparative unanimity of opinion or belief exists amongst authorities. What these "canons" are let us endeavour to describe. We have alluded to what Alison has said on the associations connected with certain forms of natural objects, inorganic or mineral, organic or vegetable, and the endeavour has been made to classify these forms, so that they can be made subservient to the purposes of architectural decoration. But in so attempting to classify them as to range under certain heads their different properties or peculiarities, the difficulty, as so clearly pointed out by Mr. Garbett, is to withdraw from the mind certain associations which give to them adventitious or conventional qualities. So that in the attempt to classify forms or ornaments, it is better to take for our model those forms which, according to this authority, are, as he terms them, "unmeaning," such as those produced in the Kaleidoscope, or those met with in "the latest form of French tracery, called the Flamboyant;" all forms which depend upon their "abstract beauty," that is, quite independent of preconceived ideas or associations which we might otherwise attach to them if the forms were derived from natural objects. This eminent authority, therefore, in analyzing conventional forms, has thus classified the "properties" which they possess, as applicable and giving expression to architectural works; "first, equal-spaced repetition, exemplified in all descriptions of diaper patterns;" and of which he elsewhere observes, "nothing is more essential, therefore, to the first aim of architecture than this equal spacing," and to secure it in an extensive building, much "thought and contrivance" must be given to the natural arrangements—which displaying itself by the exterior will give a dignity to the structure, for, as we have elsewhere observed in this Essay, where the evidence of *mind* is, nothing can be mean. The second property of ornaments, as classified by Mr. Garbett, is the "uniformity of halves," which he designates the "most universal quality in nature, pervading all ranks of organic life from the leaf and the flower up to man; and all separate and distinct creatures, even when inorganic, form a crystal to a world." The third property of ornament is "preference of curves to straight lines." This is universal; for although straight or rectilineal lines are introduced into all architectural forms, they are so introduced either for the purpose of construction or to give a value—as a set-off—to the curved lines. The fourth property is "preference of curves of contrary flexure to those which have no such contrariety." "Every one," he says, "has heard of Hogarth's 'line of beauty.'" The fifth property is "preference of curves of varying curvature to circular ones." "The main difference," he remarks, "between Greek mouldings and Roman ones, between Greek vases and Chinese, is that the former are composed with outlines of continually varying curvature, and the latter with circular ones." The sixth and last property of ornament, or that which true ornament should possess, is "unity or consistency of character;" and, in connection with which, Mr. Garbett remarks, "mixtilinear form or ornament is, in general, less beautiful than either that which is composed entirely of straight or entirely of curves." The best effect is obtained "when the straight and the curved lines are equally distributed throughout, and especially when a general principle is seen to govern their use, that is, when all the straight parts have something in common *besides straightness*, and all the curved parts some common quality *besides* their curvature."

13. In addition to those "proximate principles of *beauty in form*," Mr. Garbett states a generalization which "reduces them all to a broader principle, though still only a proximate one," which is the "combination of unity with variety," and which he explains by giving Dr. Hutcheson's axiom, "that where the uniformity is equal, the beauty of forms is in proportion to their variety; and where their variety is equal, their beauty is in proportion to their uniformity." In any good design "the points of resemblance and the points of difference must be about equal." If the former predominate in number, we say the design is monotonous or wanting in variety. If, on the other hand, the points of variety are greatly more numerous than those of unity, we call it *confused*, or wanting in character, (*i. e.*, self-consistency). Mr. Garbett goes on to show how this combination of unity with variety may be obtained by attending to two principles—first, of "gradation;" and second, of "contrast;" of which principles, he says in another part of his work, "angles are instances of the most abrupt contrast between the directions of their component lines, while curves owe their beauty to gradation. Of these two qualities, contrast is certainly that calculated to excite, and gradation that calculated to soothe." While showing that contrast and gradation are obtained by straight and by curved lines, Mr. Garbett explains, that between these two "extreme styles of form," the application of which gives us the principles of contrast and gradation in their fullest development, there are others which, approaching by degrees within the one or the other—the severe straight or the elegant curved line—will be fitted for application to various parts where that of the extremes would be unsuited. He thus deduces five classes of forms as follows:—First, the "rectilineal and rectangular;" second, "rectilinear but oblique angled;" third, "curvilinear forms without contrary flexures;" fourth, "curvilineal forms with artificial contrary flexures," meaning, by the term, artificial flexures composed of *two* curves; the fifth class is "curvilinear forms with natural contrary flexures," meaning by "natural," flexures which are composed of one curve continued throughout. In pointing out how these five classes of forms are to be applied in struc-

tural design, Mr. Garbett states, that this will be dependent upon three elements—first, "the graver or higher character of the destination of the building;" second, "the greater or less importance of the feature itself;" and third, "its height above the ground." And from these three he deduces three rules, applicable to all classes of buildings, of which the most important points are; that "principal and structural members" of the building should not belong to a lighter class of form than the "subordinate features;" and that in a building where features of the same degree of structural importance are placed at different levels, the graver forms should be used at the lower, the lighter at the higher level. In explaining and illustrating all these principles, on which Mr. Garbett conceives the beauty of form and ornament to depend, he goes deeply into the subject in a manner as able as it is suggestive. We regret that space prevents us from here epitomizing all he has said; but by presenting him with what we have been enabled to give, we have done the reader good service, and will do him better if we can persuade him to consult the pages of Mr. Garbett's able work for himself.

14. In considering the subject of ornament, it is necessary again to allude to what Mr. Burnell has stated, (see beginning of par. 12,) namely, that it is altogether a false notion that "beauty is nowise connected with utility." As pointed out by Mr. Smirke, in his lecture on "Ornament" at the Royal Academy, "ornament is specially contradistinguished from, though not repugnant to, the simple idea of utility. . . . Ornament begins where utility ends—ornament seems to be something over and above, and besides usefulness. . . Ornament may be regarded as something intended to give pleasure to the eye without offending the dominant sense of usefulness." The same authority classes ornament under three heads—"1st, Ornamental subjects that have, or appear to have, a direct practical utility. 2d, Purely æsthetic ornament, laying no claim to any practical character; and 3d, Ornaments designed with a view to impress a particular specific character on the work so ornamented." Under the first of these heads are to be named columns, corbels, key-stones of arches, and buttresses. Under the second class come all "enriched mouldings—the bosses, scrolls, and other carvings ordinarily inserted into hollows or to friezes, and spandrils; also all crocketing, drapering, and other surface enrichments." Under the third class of ornament is placed "decorative sculpture." The "sculptor's art," says this able authority, "is eminently able to give expression to a building." In treating of ornament Mr. Smirke draws pointed attention to the "moulding," which, although the simplest member to which ornament can be applied, is of "vital importance to architecture. By a careful regard to their contours, by their breadth or minuteness, by their multiplicity, or by the sparing use of them, by their boldness or their flatness, mouldings go far to mark and determine the character of a work. They are of the highest value by their unobtrusive yet clearly defined lines in emphacizing any portion of a design. The history of our art may almost be said to be read in its mouldings."

15. If it is true that the "highest possible aim" of architecture is to "imitate *nature*," we should have no difficulty in knowing where to go for examples with which to decorate our buildings. But there is a much deeper meaning in the term "imitate" than appears at first sight. It may mean a close imitation of the minute details of her works, or it may mean an imitation merely of the spirit in which she works, or of the manner in which she does her work. If the object of the decorator is to produce so exact an imitation of a natural object, that it is said by an ordinary spectator to "be *so* like it," he may rest assured that he has not succeeded in bringing out an artistic but rather a deceptive work. Opinions, however, differ on this. Ornamentists or decorative artists have, therefore, been divided into two classes, the "realistic" and the "conventional"—or those who aim at a close reproduction of the objects of nature selected for decorative purposes, and those who aim only at working in the way in which nature herself does. Upon the whole we incline to the opinion that it is the true way to *conventionalize* all our imitations of natural forms—it is quite evident, that all close imitations must be failures, for we cannot possibly "represent the minuter subtleties of nature," so that "some departure from exact resemblance is a practical necessity."

16. The *materials* with which the architect proposes to perpetuate his design have a close connexion with its *artistic* expression. And here the first thing which we notice is, let truth be displayed in every detail; do not work in stucco or cement, and pretend—by miserable imitative efforts—that it is stone—nor in wood, and by gaudily gilding it affect it to be beaten gold. There can be, and there is—no matter what the adherents to certain schools may say to the contrary—no real honest objection to the use either of stucco, cement, or of wood, if you only use them honestly, so that they will be taken for what they really are. How soon will our mere decorators—not architects—learn that all deception is mean, worthless, and base. Again, as Mr. Ruskin, with his usual eloquence and force, remarks; artistic work must be so done that it will bring out the "distinctive character" of the material used, and he states the reason of this to be, "that if you don't want the qualities of the substance you use, you ought to use some other substance: it can be only affectation, and desire to display your skill that lead you to employ a refractory substance, and therefore your art will all be base. Glass, for instance, is eminently, in its nature, transparent. If you don't want transparency, let the glass alone. Do not try to make a window look like an opaque picture, but take an opaque ground to begin with. Again, marble is eminently a solid and massive substance. Unless you want mass and solidity, don't work in marble. If you wish for lightness, take wood; if for freedom, take stucco; if for ductility, take glass. Don't try to carve feathers, or trees, or nets, or foam, out of marble. Carve white limbs and broad breasts only out of that. So again, iron is eminently a ductile and tenacious substance—tenacious above all things, ductile more than most. When you want tenacity, therefore, and involved form, take iron. It is eminently made for that. It is the material given to the sculptor as the companion of marble, with a message, as plain as it can well be spoken, from the lips of the earth-mother, 'Here's for you to cut, and here's for you to hammer. Shape this, and twist that. What is solid and simple, carve out; what is thin and entangled, beat out. I give you all kinds of forms to be delighted in:—fluttering leaves as well as fair bodies; twisted branches as well as open brows. The leaf and the branch you may beat and drag into their imagery: the body and brow you shall reverently touch into their imagery. And if you choose rightly and work rightly, what you do shall be safe afterwards. Your slender leaves shall not break off in my tenacious iron, though they may be rusted a little with an iron autumn. Your broad surfaces shall not be unsmoothed in my pure crystalline marble—no decay shall touch them. But if you carve in the marble what will break with a touch, or mould in the metal what a stain of rust or verdigris will spoil, it is your fault—not mine.'" Let this be an axiom then in the use of materials, treat each in conformity with its peculiar nature. Mr. Ferguson classifies the three materials at the command of the architect, as brick, stone, and granite; and points out how these three should be treated. Where grandeur of effect is required brick is not admissible. Where it is employed, the architect must arrange his design, so that its features will get rid of the "inherent defect of smallness and consequent ap-

parent weakness in the material." The use of tiles in the forming of arches, an expedient adopted by the Romans, and the employment of "vertical projections and reveals," may do much in attaining this object. "Horizontal projections" are also useful, but are not so easily formed; but much of their effect may be obtained by the use of "strong courses of darker colour." Where stone is used as the building material, all relief is best obtained by projecting parts. Indeed, it should never be forgot, that whatever be the material employed, if the building is flat, it will be tame and unsatisfying—both breadth and depth are absolutely essential to the character of a building. Those who design flat meaningless unsuggestive buildings, and who take all their ideas from their next door neighbour, or from the pages of books—copying without knowing principles—should travel for one single season abroad to see the fine effect produced at a cheap rate, by simply studying the effect of *depth* in the design. Truly does Ruskin exclaim, "What a strange sense of formalized deformity, of shrivelled precision, of starved accuracy, of minute misanthropy, have we as we leave the rude streets of Picardy for the market-towns of Kent. Until that street architecture of ours is bettered—until we give it some size (of parts) and boldness—until we give our windows recess and our walls thickness, I know not how we can blame our architects for their feebleness in more important work; their eyes are inured to narrowness and slightness; can we expect them at a word to conceive and deal with breadth and solidity? They ought not to live in our cities; there is that in their miserable walls which bricks up to death men's imaginations as surely as ever perished forsworn men."

17. As to *colour*, and its effect in architecture, little need be said about it, for independent of the fact that it is doubtful whether it is a legitimate source of beauty, we cannot ignore this, that our climate greatly forbids its use. Indeed, it is chiefly in brickwork that it can be adopted, and in connection with which the following remarks from the pen of an able writer in the "Building News" will be useful. In many cases where coloured brickwork is used, "there is no rest, it is all coloured brickwork; contrast there is in colour, certainly much too violent; but anything like a sober, quiet bit of repose in the building there is not. While on the subject of coloured brick, I cannot refrain from humbly drawing attention to the bright staring effect, and yet confusion, by *pointing* brickwork in white or any strongly marked manner—a great error and eye-sore to my mind at all times, but when it is desired to ornament a wall with bonds of bricks of different colours, it is destructive of all the contrast of colours intended to have been obtained by the design. A short time back I was in the habit of watching, as they grew day by day, the rising walls of a house in the course of erection. I soon saw that they were being built of white brick, crossed at considerable intervals by bands of three or four courses of red. This mode of decoration, as the house drew near completion, satisfied me very well; its effect then was as a wash of pale yellow, or stone colour, ornamented with broad, clear courses of red, not too bright; they were then each clear, defined, undisturbed surfaces of their respective colours, and in my opinion the effect was good. But one day, after not having passed by for some time, the whole effect was altered and marred; the two kinds of colour were gone, and in their place separate bricks of different colours shone at me and dazzled my eyes, each brick looking at me out of a small oblong space, bounded by staring white lines—all that was pleasing in colour was gone. The same has, I regret to say, been done in the interior of a building of much more mark and beauty; and disliking as I do the use of bricks at all in a church interior, I, who had thought better of this instance of its use than I usually do in its untouched state during the progress of the works, was horror-stricken to find that it had been pointed, and the wall apparently ornamented with separate bricks in white settings. Some may not be of my opinion as to this practice, but I would ask them to consider the object of contrast of colour intended in parti-coloured walls, and at what stage of what seems to be considered the necessary progress, the work most realizes to them their own intention in so colouring it, whether before or after pointing."

18. We have thus endeavoured, within the brief limits at our disposal, to present to the reader a *resumé* of the principles on which structural decoration depends, or upon which the best authorities conceive it to depend. As stated in the commencement of our paper, much diversity of opinion exists on all the points discussed, but that at the same time there were certain canons which were pretty generally conceded to be correct, and these we have endeavoured to explain. This much may be said in favour of these canons, that if the endeavour on the part of any one connected with the practice of construction to carry them into effect be honestly made, much benefit will result to all concerned, client as well as architect. Architecture has been called the "stony records of nations;" by others it has been designated a "petrified religion;" if after ages ever study the architecture of our time as we have studied that of Egypt, Greece, and of the middle ages, we fear that they will come to the conclusion that we, as a nation, have had no "records" to leave behind, no "religion" to embalm in stone. Possibly this may be a thing not much, if at all, to be regretted, seeing that "copying" the records of other nations is thought by some to be sufficiently useful for all our purposes. If so, the main thing to be done is to ensure that we copy correctly so as to embody the same principles which guided the architects of the works we aim at reproducing; and we may have done some service if we have only pointed out what these principles are, and how they can be attained. Much has been written of late as to a "new style;" it will possibly be a good thing for the future of architecture if we see around us evidences that the old styles have been first understood by us, and that we have learned the lessons which the principles they embody are so well calculated to teach us. Having learnt these, there will be a good chance of a new style being produced amongst us; till this is done we fear but little. New style or old style, if the architectural designer aims at truth and consistency, and endeavours to carry these out with earnestness of thought and purpose, he may trouble himself but with little else. Truth and consistency aimed at, and earnestness of thought and purpose given, he will produce a structure which will tell its story and give evidence of mind; and where this is—we have said it before, but it will bear repetition—there will be satisfaction. The story of the structure, after all, may not be told in the best way, but it will be original, and, like Aubrey in the play, when apologetically introducing his wife—no great beauty—its architect may say, "She is a poor thing, Sir! but she is *my own*." A thing not always to be said truthfully in these, the "sad days of a degenerate architecture."

ON

THE PRINCIPLES INVOLVED

IN THE

ARRANGEMENT AND CONSTRUCTION OF TIMBER AND IRON FRAMING.

1. It is impossible to over-estimate the value of a knowledge of the principles involved in the construction of framing to the mechanic who is to design and erect it. For not only is economy of material secured by having this knowledge, but the safety of the structure also, on the stability of which so much depends. Yet notwithstanding the importance of this branch of knowledge, it is somewhat surprising how rarely it is so thoroughly mastered by the ordinary run of mechanics as to influence their practice. This may be said, perhaps, to hold more particularly true of the mechanics of rural districts. Some, however, are met with, who have a singularly marked intuitive knowledge of the strength of materials, and who rarely in their construction give an overplus or a deficiency of material, but generally hit the happy medium. But even in such cases a correct knowledge of the principles which regulate their practice cannot but be of the highest value. For by it they will be enabled to advance in a capability to design and construct, feeling the firmness of the ground, so to speak, upon which they tread, and having a knowledge of the direction in which it leads them, they will inevitably go surer, and in going surer go faster in that path which leads, if not to eminence, at least to that useful position in which their work is always well done, because it is done on right principles. But if a knowledge of these principles is important to those who rarely make grievous mistakes in construction, through the intuitive notions above alluded to, it is of infinitely greater importance to those who are alike ignorant of that help which "science" as well as the "rule of thumb" bestows. But to both of those classes of mechanics above alluded to, the suggestiveness of the truth may be pointed out, that although a construction may be safe it may not be scientifically correct, and because not scientifically not economically constructed. A beam, for instance, may not give way to the pressure which it is placed to sustain, and being stable, it passes for being correctly formed and placed. It may not, however, be so, for its stability may be secured by an extravagant expenditure of material, which in the single beam may not be a matter of any moment, but where the beam is multiplied by dozens becomes an exceedingly important item in the cost of construction. But the scientific constructor, knowing that the strength of a beam is not secured alone by its *form*, but also by the *position* in which it is placed, and in the *manner* in which it is loaded, can at once point out the errors of the non-scientific constructor, and in designing, design not only a correct, but economical beam. The same remark applies to columns and roofs, and all framed work, and goes to prove the importance of a knowledge of the principles involved in the construction of framing. What these principles are we now propose briefly to explain.

2. *Strains to which materials used in framing are subjected.*—Materials, when placed in structures, undergo a variety of strains according to the position in which they are placed. These are called "tensile" and "compressile," "cross strains," or "transverse pressure."

3. When a block of stone or wood, or an iron pillar *a*, as in fig. 1, is subjected to the pressure of a block or weight *b*, acting in the direction of the arrow *c*, the pillar is said to be subjected to a "*compressile*" strain, or to "compression," the molecules or atoms of iron being compressed or squeezed closer together.

Fig. 1.

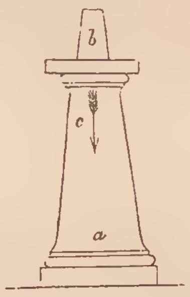


Diagram illustrating compressile-strain.

4. But suppose the pillar to be suspended, its upper end being fixed to a beam, then it is subjected to what is called a *tensile* strain, or to tension, the weight of the lower part tending to tear asunder the molecules of the upper part. Thus, in fig. 2, the pillar *a* is suspended from the beam *b b*, and pulled downwards by the weight *c* in the direction of the arrow *d*; the pillar *a* is subjected to a tensile strain, the weight *c* acting as the force which tends to *tear asunder* the particles of *a*, just as the weight *b* in fig. 1 acts as the force to *crush or squeeze the particles of a together.* So, in like manner, is the rope or chain *e*, fig. 2, subjected to a tensile strain by the weight *f*,

Fig. 2.

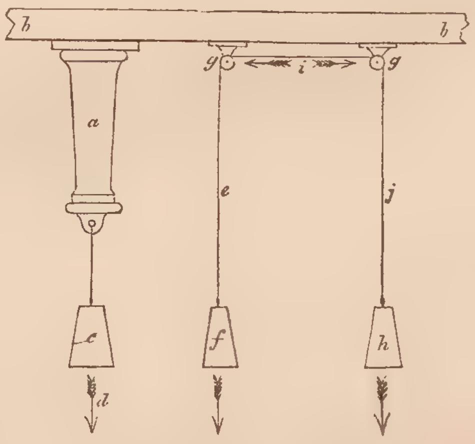


Diagram illustrating tensile strain.

the chain or rope being supposed to be fixed to the beam *b*; but if it is passed over two pulleys *g g*, and the other end terminated by a weight *h*, then the part *i* is subjected to a tensile strain, the weights *f* and *h* tending to tear it asunder in the direction of the arrows as shown. The part of the chain *j* is also subjected to a tensile strain.

5. When a beam as *a a* fig. 3, is supported at both ends on the walls *b b*, and pressed upon by a weight, as *c*, or pulled downwards by another weight suspended from the link *d*, the resistance which the beam *a a* has to be broken by the weights is called resistance to *transverse or cross-strains.*

Fig. 3.

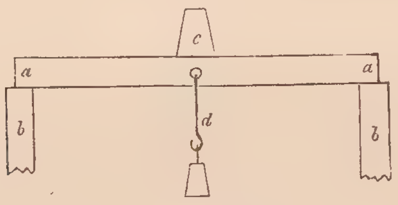


Diagram illustrating a cross strain.

6. When a beam, as *a a*, fig. 4, is supported at the ends on the walls *b b*, it has a tendency to bend downwards, as shown in an exaggerated form at *c*. This bending is technically known as the "*deflection*" of the beam, and its resistance to this tendency is termed its "*elasticity*," or "*resiliency*."

Fig 4.

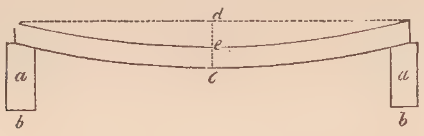


Diagram illustrating deflection of Beams.

7. A beam, placed as in fig. 4, has its upper and lower sides placed under different kinds of pressure. Thus, suppose the beam to have two parts cut out, as at *a* and *b*, fig. 5, one on the lower, as *b*, and one on the upper side, as *a*, these two cuts would not change in form, if the beam was allowed to rest quiescent on the ground; but if it was placed between, and its ends supported by walls, as in fig. 4, bringing its deflective tendency into play, then the cuts would assume different forms; thus, the upper cut would close, a ball *c* placed in it being squeezed closely together by the sides of the cut being pressed in the direction of the arrows *d e*; while, on the other hand, the lower cut *f* would open, its sides being separated in the direction of the arrows *f g*, allowing the ball to drop out as shown in the diagram. The upper side of the beam is thus shown to be subjected to "compression," the lower to "tension." The line *h h* represents what is called the *neutral axis* of the beam, this being subjected neither to a tensile or a compressile force. The neutral axis is theoretically nearly, but to all practical purposes may be said to be, in the centre of the beam, at a point equidistant from its upper and lower sides.

Fig. 5.

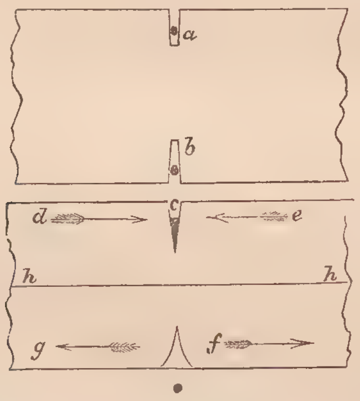
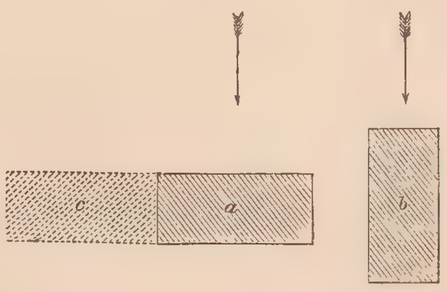


Diagram illustrating tensile and compressile strain of a beam resting on walls at its extremities.

8. *Strength of Beams as their Position or Form.*—The resistance which beams sustain when subjected to transverse pressure or cross-strains, as in fig. 3, increases *directly* as their breadth increases—that is, suppose a beam *a*, fig. 6, to be capable of supporting a certain weight; by doubling this breadth, as shown by the dotted-lined part *c*, the strength is merely doubled. But as the strength of beams increases as the *square* of their depth, a much stronger beam is obtained by placing the beam *a* in the position as at *b*. Thus, suppose the depth of the beam *a* to be 8 inches, and its breadth 16 inches, the square of this, or 8 multiplied by 8, would give 64, representing its strength "on the flat"—as the technical phrase is; but by placing the beam "on edge"—making the breadth of *a*, that is 16 inches, the depth—the square of this 16 × 16 will give 256 as representing the strength of the beam in its new position. *By merely changing, then, the position* of the beam *a*, fig. 6, from the flat to the edge, a quadrupled strength is obtained. A familiar but striking illustration of the increase obtained by placing beams upon their edge instead of flat is met with in an ordinary saw, which, if weighted with a slight weight on the flat side, gives way at once, but will support without change of form a much greater weight placed upon its edge.

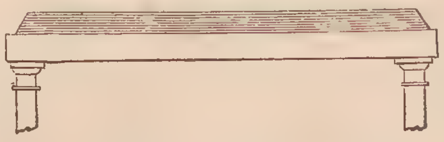
Fig. 6.



Strength of Beam as Position or Form.

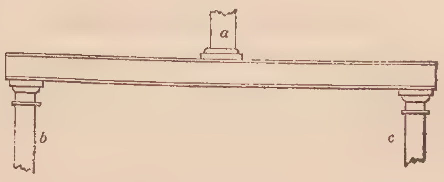
9. *Strength of Beams as Loaded.*—But the manner in which beams are loaded, or in which they sustain the pressure, exercises an exceedingly important influence on their strength to resist cross-strains. Thus, a beam will support *double* the weight when placed or distributed over its whole length, as by the bar *a* in fig. 7; as compared with an exactly similar beam, fig. 8, supported as before on pillars or walls *b c*, which receives the pressure as of a column *a* exactly in the middle of its length. The beam in fig. 7 is capable thus of bearing twice the pressure of that in fig. 8.

Fig. 7.



Beam with weight distributed over surface.

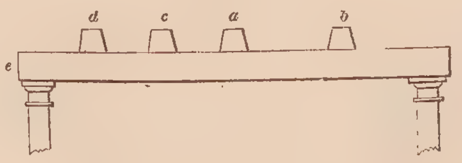
Fig. 8.



Beam with weight or pressure at centre.

10. From the statement in last paragraph, it will be perceived that weights placed at different points, as *a*, *b*, *c*, *d*, fig 9, on the beam *e f*, will exercise pressure different in amount,

Fig. 9.

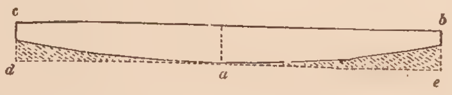


Beam with pressure at different points.

the pressure decreasing as the weight is placed nearer any of the points of support, as *e* or *f*.

11. This difference of pressure at different points of a beam supported at both ends enables us to have the beam of different depths at different points. In the form in fig. 10 the greatest depth is at the centre *a*, gradually tapering off on each side to half the depth at the ends *b c*. A beam of this form is as strong as when the depth is uniform throughout, as *c b e d*. The bottom line should assume the form of the parabolic curve.

Fig. 10.

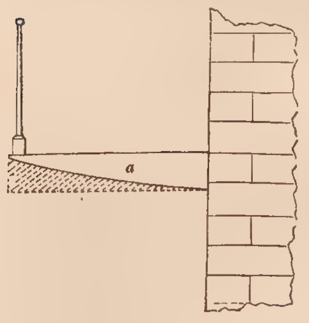


Theoretical form of beam.

12. The capability of a beam to resist cross-strain is also greatly influenced by the distance between the supports. This capability is "inversely as the square of their depths." Thus, a beam 6 feet between the supports will support a weight or pressure four times that of a beam 12 feet between the supports. Stated thus, $6 \times 6 = 36$, and 4 times this is 144, which is the same as the square of 12. To ascertain the relative strength of beams, the space or distance between the supports must be taken into account when calculating. Thus, suppose a beam is 12 inches deep and 6 inches wide, and the space 8 feet, then square the depth and multiply it by the thickness, dividing the amount by the space, $12 \times 12 = 144 \times 6 = 864 \div 8 = 108$. This beam is on the edge, its strongest position; on the flat its strength will be $6 \times 6 = 36 \times 12 = 432 \div 8 = 54$.

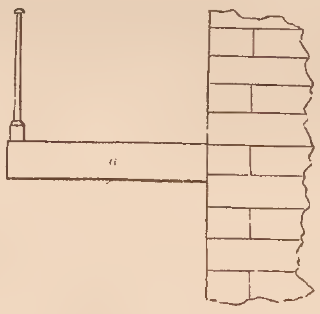
13. In fig. 10 we have shown how a beam may be reduced in depth as it approaches its supports without weakening it, the depth diminishing just in proportion as its liability to fracture diminishes; we now exemplify other modes by which material is saved in the formation of beams. Thus, the beam *a* in fig. 11, which may be supposed to support the landing of an outside staircase, is as strong with the part cut away, represented by the dotted lines, as where the depth is uniform throughout, as in fig. 12.

Fig. 11.



Triangular form of Projecting Beam, with pressure at extremities.

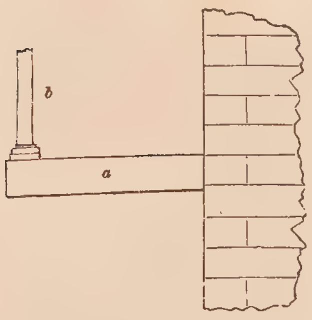
Fig. 12.



Projecting Beam with weight or pressure at outer end.

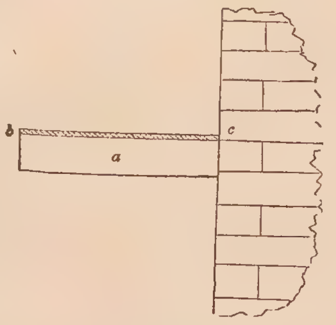
14. But the influence of the disposition of the load on beams supported at one end is just as marked as in those supported at both ends, and as stated in par. 9. Thus, where a beam *a*, fig. 13, projecting from a wall has the pressure applied to it directly at one end, as through the pillar *b*, it will support only one-half of the pressure which a like beam, *a*, fig. 14, will support where the load is distributed over its entire surface, as through the medium of a flagstone, *b c*. The beam, under the circumstances, as illustrated in fig. 13, will only carry a load one-fourth the amount—not one-half as might be supposed—which a beam, as in fig 8, will carry.

Fig. 13.



Rectangular Projecting Beam with pressure at extremity.

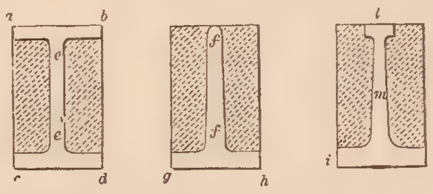
Fig. 14.



Projecting Beam with weight over surface.

15. Where the material admits of it, as by the use of cast-iron, an immense saving of material is effected without lessening the safety or strength of beams by altering the cross-section. Thus, let *a b c d*, fig. 15, represent the rectangular form of a cast-iron beam; material will be saved to a large amount by forming the beam as *c d*, *e e*, *b a*, all the parts shown by dotted lines being cut away, and this can be done without weakening the beam. This form is known as *Tredgold's* section of beam.

Fig. 15.



Tredgold's, Fairbairn's, and Hodgkinson's section of iron beams.

16. By cutting off all the parts, leaving a central rib *f f* and bottom flange *g h*, *Fairbairn's* section of beam is obtained.

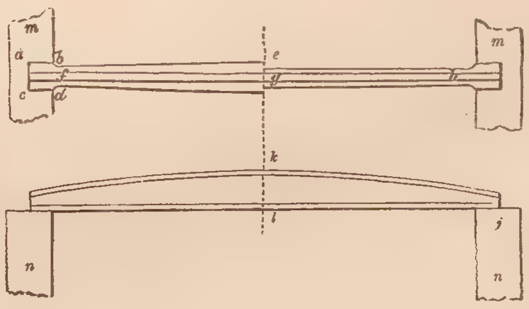
17. By cutting off all the parts, leaving a top flange *l*, a central rib *m*, and a bottom flange *i k*, *Hodgkinson's* section of beam is obtained.

18. Of these three forms, Hodgkinson's, *l m*, *i k*, fig. 15, is the strongest, and is that now universally employed in good construction. Taking the strength of *Tredgold's*, *a b*, *c d*, *e e*, fig. 15, at 2,368 lbs., as the breaking weight of a beam supported at both ends, the breaking weight of *Fairbairn's*, *g h*, *f f*, fig. 15, is 2,886, and of *Hodgkinson's*, *l m*, *i k*, fig. 15, 3,825.

19. The *position* in which Hodgkinson's beam, *i k*, *l m*, fig. 15, is placed, exercises an important influence on the strength of it. Thus, if the beam is placed with the small flange *l* lowest, it will bear little more than half as much as when the widest flange, *i k*, is placed lowest. Supposing the strength of the beam placed as at *i k*, *l m*, fig. 15, to be represented by 100, its strength when placed in the reversed position—that is, with the small flange *l* lowest—will be only 65.

20. Fig. 16 shows plan and elevation of a beam of Hodgkinson's section. The bearing surfaces of the beam on walls *m m*, or columns *n n*, should be square, *a c b d*, the side of the square being equal to the breadth at centre of beam *e*. The width of bottom flange at *f* should be half that at *e*, the outline being curved in the parabolic curve. Where the beam is used to support bricks resting on the lower flange, it may be of equal width throughout, as shown at *g h*. In the side elevation the ends *i j* are of less depth than the centre *k l*, the outline being parabolic. The depth of cast-iron beams is often, however, uniform throughout their length.

Fig. 16.



Plan and elevation of Iron Beams.

21. In using cast-iron beams for any erection, it is advisable to insert a stipulation in the contract that they shall be *tested* up to a certain point. It is, however, of the highest import-

ance that this testing should be carefully and judiciously done. There is no doubt that as testing is frequently performed it does more harm than good. Beams are frequently tested up to a certain point, which point is doubtless within the breaking point, but nevertheless so near to it that the beam is permanently weakened, and is never again so strong as it originally was. The beam is, in fact, over-tested, which over-testing has brought about the very weakness, the finding out of which was the purpose of the operation. The process of testing in many cases, by disturbing the molecules of the iron of the beam, brings it into a state of weakness. Mr. Fairbairn, the eminent authority on all points connected with the use of iron in construction, has the following remarks so pointed and pertinent that we do our readers a service in giving them here. We are indebted for them to the work of this celebrated engineer, "On the Application of Wrought and Cast-iron to Building Purposes," p. 163. London: J. Weale.

> "A competent knowledge of a few leading principles which affect the strength of materials will enable us to determine the tests which it is requisite to employ in cast-iron, in order to detect flaws and defects (if any exist) in the castings. * * * As an evidence of injuries done to beams by excessive tests, let us suppose that we load a beam (supported at both ends and loaded in the middle) to within one-twentieth of the weight of rupture, say 950, and that 50 more would break it. From this it is obvious that nearly the whole of the resisting power of the beam on both sides of the natural axis are brought into play, and are suffering under some severe pressure at the very point of rupture. Supposing, again, that we remove the load, and ascertain by actual measurement the effect of the tests to which it has been subjected, we shall then find that it has not only received considerable injury in its elastic powers, but is actually in danger of fracture from a repetition of the same load. Now, what is the result of a less severe strain? The beam, when loaded to one-third of the weight that was placed upon it, was in possession of powers that restored itself within a fraction of its original position; whereas, with the heavy load it is seriously crippled, and a few more charges, even with reduced weights, would, from the derangement which the molecules, or particles, had sustained in the first instance, and the repeated alternation of removing and reloading, shortly destroy its powers of resistance and cause fracture. It is for these reasons that I have always been opposed to severe proof on cast-iron beams, or those of any other material; and I have no hesitation in dealing with those useful constructions in recommending a moderate test of about one-third, and that rather for the purpose of detecting flaws and imperfections in the casting than for the determining the ultimate strength of the beam. The resisting powers of beams (of whatever material they may be composed) are like the muscles of the animal frame when strained beyond their reasonable powers of resistance. They may for a time endure the load, and probably a few repetitions of it, but the result generally is either the rupture of the several parts or the total suspension of those powers by which their elasticity and powers of restoration are maintained."

22. To secure a proper mode of testing, the following procedure may be adopted. Let a sample beam be chosen and loaded with a gradually increasing weight, carefully noting at each increase of load the deflection which the beam makes. Continue the load till it breaks. Let all the other beams be loaded in the same manner with like increase of weights, and if the deflection at the various stages corresponds with those of the trial beam, the beam may be passed as safe. But in place of loading all the beams up to the breaking point, they should be loaded up to one-third only of that which broke the trial beam. Greater safety will be secured if the beams are loaded only up to one-fourth of the breaking point of the trial beam.

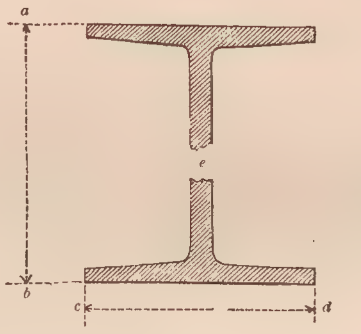
23. Should all this care be objected to as tedious and costly, the only other way open to the constructor is to calculate from a proper formula the size of the beam required to carry a certain weight, making this weight one-third, or safer if one-fourth, of the breaking weight of the beam. The castings should then be intrusted to a party on whose integrity full reliance can be placed, so that the quality of the iron stipulated for, shall really be supplied.

24. Good castings will likely be secured if the stipulation is made and adhered to, that the castings will not be taken out of the sand till they are allowed to cool. The practice, too often followed by iron-founders, of taking castings out of the sand red-hot, cannot be too highly deprecated. Of course, the folly of dashing cold water on them in addition is still more to be denounced. If beams, moreover, can be cast vertically, that is, in the direction of their length, they will be stronger than if cast horizontally, which, however, being the most convenient way, we need scarcely say is the ordinary method adopted. If the iron melted in an air cupola can be obtained, it should be preferred to that melted in the ordinary blast furnace, as the beams cast from it will be stronger.

25. Wrought-iron beams are now coming much into use, as, with great lightness, they are very strong. Thus, if two beams, calculated to bear the same weight, but one of which is of cast the other of wrought-iron, the cast-iron beam will be 2½ times heavier than the wrought-iron beam. Wider spans can also be obtained by the use of wrought-iron beams than by cast-iron.

26. Wrought-iron beams are now rolled in one piece solid, as shown in figs. 17 and 18, which are forms manufactured by Messrs. Mather, Ledward, & Co., Liverpool. In fig. 19 we illustrate a wrought-iron beam as introduced by Mr. Fairbairn, in which *a a* is the central part, made of flat sheet iron, with the angle irons *b b*, *c c*, placed on each side, and along the top and bottom. These being rivetted to the plate, *d d* is the side elevation. In fig. 20 we illustrate the "box beam" of wrought-iron, also introduced by Mr. Fairbairn, *a a* the side plates, *b b* the top and bottom plates, *c c* the top, *d d* the bottom angle bars, *e* the side elevation.

Fig. 17.



Section of rolled wrought-iron Beam.

Fig. 18.

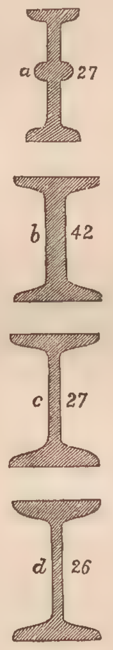
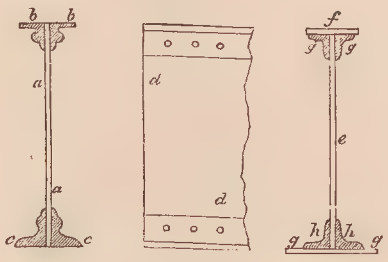
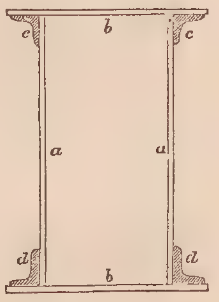


Fig. 19.



Wrought-iron Beams.

Fig. 20.



Box Beam.

27. The dimensions of a cast-iron beam of section, shown in fig. 33 at *k l m n*, 18-feet long, calculated to bear a weight on flooring, the floor surface being equal to 134 superficial feet, of 172 cwt. per foot, are as follows:—The total depth of girder. 16 inches; width of lower flange *k k*, 16 inches;

width of upper flange *m n*, $4\frac{1}{2}$ inches; thickness of lower flange at thickest part, $3\frac{1}{2}$ inches; at the edges $1\frac{3}{4}$ inch; thickness of the upper flange, 1 inch; thickness of central rib at bottom, $1\frac{3}{4}$ inch; at top 1 inch.

28. Dimensions of beams of various depths, and for various spans, and to support $1\frac{1}{2}$ and $2\frac{1}{2}$ cwts. per superficial foot, will be found in a very full series of tables in Weale's Engineer's Pocket Book. The weight of the beam of the above section may be assumed to be about 25 cwt., and the cost of casting to be from 5s. to 7s., according to circumstances.

29. To find the permanent load, assuming this to be one-fourth of the breaking weight of the beam—a very safe allowance—of a cast-iron beam, the following rule is given:—"Multiply the area, or superficial section in inches, of the bottom flange by the total depth, also in inches, and divide the product by the length of the beam in feet, the quotient will be the load in tons which may be safely distributed over its entire length, or one-half of the weight, which may be safely suspended from, or made to bear upon, its centre."

30. The following, as to the bearing, strength, and weights per lineal foot of rolled wrought-iron beams of section, as in fig. 17, will be useful. They are prepared from data kindly furnished us by Messrs. Mather, Ledward, & Co., Liverpool, makers. Where the total depth of the beam is 12 inches, and width of flanges $4\frac{3}{4}$ inches, the length being 19 feet, the permanent load in the centre should not exceed 15,015 lbs., uniformly distributed over its surface 24,948 lbs. The weight per lineal foot of this section of beam is 44 lbs. Where the depth is $7\frac{3}{4}$ and width of flanges $4\frac{3}{4}$ inches, the length being 19 feet, the permanent load at centre is 7,700, and uniformly distributed 12,800 lbs.

31. The weight per lineal foot of this section is 34 lbs. Where the total depth is $4\frac{5}{8}$ inches, width of top flange $3\frac{3}{8}$, of bottom do. 3 inches; the weight at centre is 1,840, uniformly distributed 3,080 lbs. The weight per lineal foot being 15 lbs. By building the ends of the beams into the walls a distance equal to three times the depth, one-third may be added to the permanent load.

32. Of the relative merits of cast and wrought iron for construction, we must here say a few words. Cast-iron undoubtedly offers great facilities for working, being easily moulded into any desired shape; it is on this account highly esteemed by our country mechanics. It is nevertheless a very treacherous material, one on which little dependence can be placed. It often fails when least expected, and in a manner which no calculation could foresee or prudence avoid. It frequently breaks, and that so suddenly as to give no forewarning; exposure to atmospheric influences causes it to fracture; "the rupture," to quote Mr. Fairbairn, taking place "with a loud noise like the snapping of a pistol." This liability to fracture, as sudden as it is dangerous, arises from the unequal shrinking and contraction in cooling. And it is just because this contraction cannot be, or at all events is seldom regulated or under control, that there is such danger in the use of cast-iron. For the truth is, that, not knowing the real condition in which the beam exists, we cannot predicate with certainty its real and trustworthy capability to resist fracture. Cast-iron also, from its crystalline texture, unlike that of wrought-iron, which is fibrous, is more brittle and liable to fracture. Moreover, a danger, not the less dangerous because it is hidden from observation, arises from the existence of internal flaws, weakness, and hollows, beneath the external crust or coating, which appears thoroughly sound.

33. Wrought-iron, on the other hand, less in bulk, has greater strength to resist strains of a tensile character, and can be disposed in such a manner as to possess great resistance to cross strains. Cast-iron beams, from their rapid increase of weight as their length increases, are confined to short lengths; so that columns or supporting points are often required, thus cutting up considerably the internal space of a building; whereas wrought-iron beams can be made of much greater lengths; indeed there is scarcely any practical limit to their span so far as buildings are concerned. Wrought-iron as used in beams is, from the nature of the processes which it undergoes in its manufacture, perfectly free from all internal defects, flaws, &c., which, as above noted, weaken cast-iron beams. Another great advantage possessed by wrought-iron is that it can withstand the action of fire much longer than cast-iron, which rapidly gives way, and twists, yields, and breaks under it.

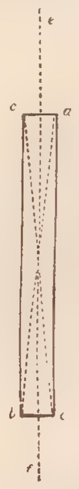
34. *Columns or Pillars of Iron.*—In designing columns of iron it is of the utmost importance to have the bearing surfaces flat. Mr. Hodgkinson, to whom the scientific world is so much indebted for his investigations on beams, has also given this department of columns his attention. The following is a resumé of the result of his investigations on the bearings of columns. A pillar, with its ends perfectly flat, and fixed immovably, was found to be *three times as strong* as a pillar with one of its ends rounded, and jointed to an upright, in the same way as the jibs of some cranes are jointed to their vertical columns. Taking three pillars of equal diameter, as 1, 2, and 3, fig. 21, one as (3) having its ends perfectly flat, a second (2) having one end flat and the other rounded, and the third (1) with both ends rounded, then their strength would be as 1, 2, and 3, that is, 2 would be twice as strong as 1, and 3 would be three times as strong as 1.

Fig. 21.

Forms of Termination of Pillars.

35. Another point of importance in columns is to set them perfectly plumb, that is, the central axis absolutely perpendicular to the plane of the base. Mr. Hodgkinson has pointed out the importance of this, as illustrated in fig. 22. Thus, if the pressure is applied in the direction of a diagonal line from top to bottom of pillar, as *a b* or *c d*, fig. 22, the strength of the pillar to resist compression is reduced as much as two-thirds. That is, a pillar to which the pressure is applied in the direction of a diagonal line as *a b*, has only one-third the resisting capabilities of a pillar in which the pressure is applied in the direction of the perpendicular line *e f*.

Fig. 22.



Resistance in Pillars as direction of Pressure.

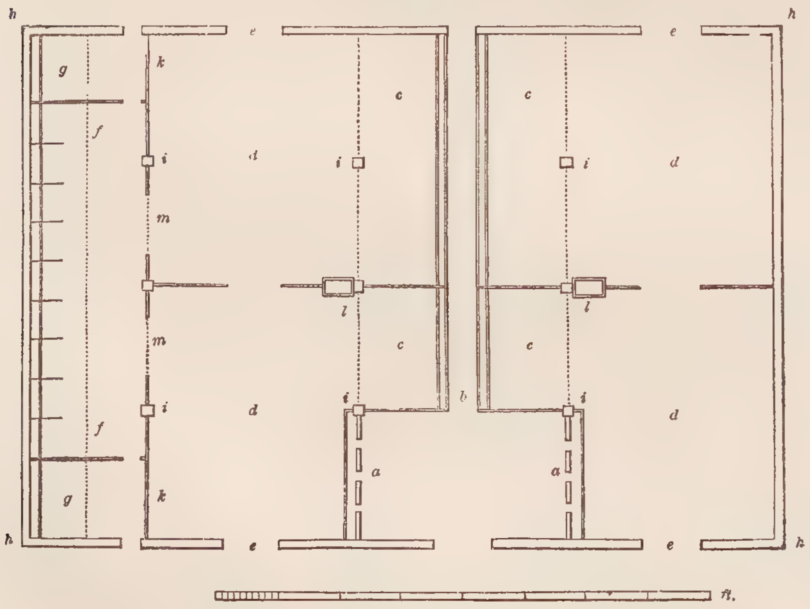
36. The following matter as to dimensions of cast-iron columns to carry different weights, is deduced from tables given in Weale's Engineer's Pocket-Book, 3s. This work should

form an essential part of every practical man's library, as it contains a vast mass of calculations which could only be elaborated at the expense of much time and labour. The diameter of columns is equal throughout, the height being taken at ten feet; the weight supported being given, as also the extent of flooring in superficial feet which the pillars will support, giving to each foot a load of $2\frac{1}{2}$ cwt., e. g. diameter of column 5 inches, thickness of metal $\frac{1}{2}$ inch, weight supported 6 tons 10 cwt., extent of flooring 65 feet. With the metal $\frac{3}{4}$ inch in thickness the weight supported is 9 tons 15 cwt., extent of flooring 97 feet. With the thickness of metal 1 inch, the weight supported will be 13 tons, and extent of flooring 130 feet. Where the diameter of pillar is 6 inches, thickness of metal $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, the weight supported and extent of flooring will be respectively $8\frac{1}{2}$ tons 85 feet, 13 tons $130\frac{1}{2}$ feet, $17\frac{1}{2}$ tons 175 feet. Where the diameter is 7 inches, and thickness $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, the weight supported and extent of flooring obtained will be respectively $10\frac{1}{4}$ tons 102 feet, 16 tons 160 feet, $21\frac{1}{2}$ tons 215 feet. Diameter of column 8 inches, thickness of metal $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, weight supported $18\frac{1}{2}$ tons, 23 tons 15 cwt., $27\frac{1}{2}$ tons; extent of floor 185, 237, and 275 feet. Diameter of column 9 inches, thickness $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, weights $22\frac{1}{2}$ tons, $26\frac{1}{2}$ tons, and 35 tons; extent of flooring 225, 265, 359 feet. In same table will be found the diameter of column from 3 inches up to 18, and extent of flooring calculated for $1\frac{1}{2}$, $2\frac{1}{2}$, and 3 cwt. to the superficial foot.

37. The weight of a 10 feet pillar 5 inches in diameter and inch thick may be set down at 220 lbs., not including the base and cap, which may be reckoned at 40 to 80 lbs. extra, according to degree of ornamentation. The same pillar $\frac{3}{4}$ inch thick will weigh about 310 lbs., cap and base from 2 to 4 times the weight of a lineal foot, namely 31 lbs. The weight of a pillar 5 inches diameter and 1 inch thick, may be set down at 390 lbs., the cap and base from 2 to 4 times the weight of a lineal foot, say 39 lbs. The weight per lineal foot of a column 6 inches diameter, having thicknesses of $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, will be 27, 28, and 49 lbs. Of a column 7 and 8 inches diameter, with thicknesses of $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch, 31, 46, and 58 for the 7 inch, and 36, 53, and 68 for the 8 inch diameter; and for 9 inches of the above thicknesses 41, 60, and 78 lbs.

38. *Construction and Fitting-up of Columns and Beams.*—In order to exemplify the use of iron columns and beams in the construction of buildings, we give in fig. 23 an illustration of part of a farm building or steading. In this the separating walls are of brick or of stone, the internal supports for the roof resting upon columns placed at the points *i i i i i i*. In place, however, of the outer walls being made of brick or of stone, the space may be enclosed by a series of pillars or columns at intervals in the line of enclosure *h h h h*, the spaces between the pillars being filled up with wooden boarding or galvanized iron or corrugated zinc. The latter, with a roof and internal partitions of the same materials, would make the building absolutely fireproof.

Fig. 23.

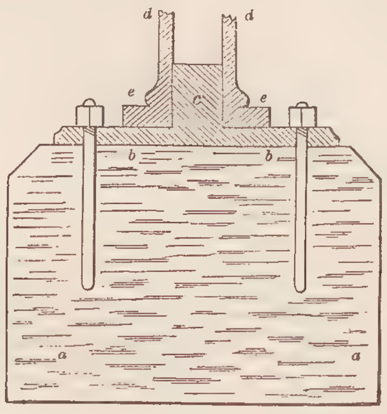


Plan to illustrate disposition of Columns and Bearers in supporting Roofs.

39. The plan illustrates the arrangement of cattle courts *d d d d*, and cowhouse, byre, or shippon *f f*, which has also loose boxes *g g*; the turnip store is at *a a*, the feeding passages at *b b*; *c c c c* the feeding sheds attached to the courts *d d d d*. The gates leading to cattle courts *d d d d* are at *e e e e*. Dunging gates may be made to the cowhouse at *m m*.

40. The dimensions of the columns at *i i i i i i* are as follows: height over all ten feet, diameter at lower part *d d*, immediately above the base *e e*, fig. 24, 5 inches, at top part *a*, immediately below plate *f f*, fig. 31, 4 inches. The columns to be cored or hollow throughout, diameter of core 3 inches.

Fig. 24.

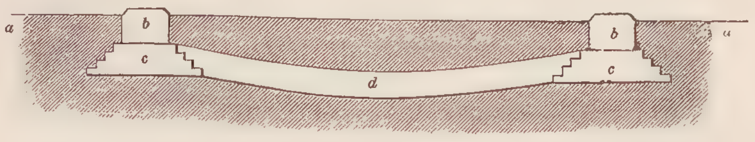


Fixing of Base of Iron Column.

41. *Iron Columns.*—We have already—par. 34, 35—shown the importance of having the columns set "plumb" and the base flat, to secure steady bearings, so that they may resist all shocks of carts, &c. coming against them. The bases of the columns may be fitted as illustrated in fig. 24, in which the part *a a* is of brick or stone, the base plate *b b* is of cast-iron, and is bolted down to the stone *a a*, the bolts being leaded into the same. The base plate is provided with a projecting part *c*, over which the projecting part of the pillar *d e* is passed.

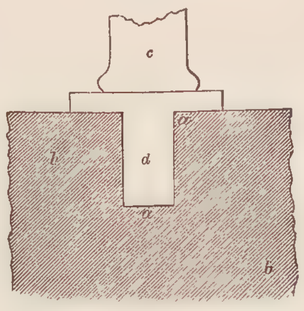
42. The bearings as in fig. 24 are placed at the desired intervals, say from 12 to 18 feet apart; but if the ground is loose, affording an unsettled foundation, it will be advisable to turn inverted arches between the bearings, as illustrated in fig. 25, where *a a* is the line of ground, *b b* the stone bearings corresponding to *a a* in fig. 24, *c c* the brick footings, *d* the inverted arch, also of brick. Where the foundation is of solid rock, the bearing may be made as in fig. 26, where an aperture *a a* may be cut in the rock *b b*, the pillar or column

Fig. 25.



Retaining or Inverted Arches for Foundation of Blocks for Iron Columns.

Fig. 26.

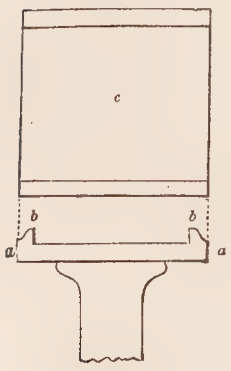


Fixing of Base of Iron Column.

c being provided with a projecting part *d*, which is passed into the aperture *a a*.

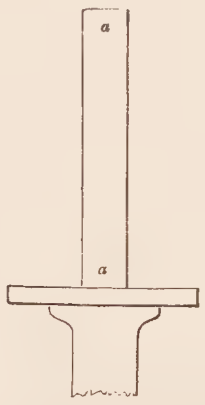
43. Where columns are used in a one storeyed building to carry the beams which support the rafters of the roof, the upper part of the column should be finished as in fig. 27, the upper plate—of which a plan is given at *c*—is provided at its outer edges with snugs or projecting ribs *b b*, between these the lower flange of the beam fits. The upper part of the column is sometimes finished with a collar *a a* as in fig. 28, this part being embraced by the ends of the beams, which are finished with circular ends. Where a wooden beam is used to support the rafters, the upper part or "cap" of the pillar is finished as in fig. 29, *a* being the beam, *b c* the projecting part into which the beam *a* is fitted; *d e* shows the plan of upper side of cap *h h*, *f f* the recess into which the beam fits. Where the columns support wrought-iron beams as in fig. 17, the "cap" of column may be made the same as in fig. 29, the recess being made wide enough to receive the lower flang of the beam, or the recess may be made of the same shape—as shown by the dotted lines *g g*—as the section of lower part of beam, the beam in this case being inserted into its place. For further security the beam may be secured to the cap by a bolt passing through the beam and the part *b c* of cap fig. 29, the whole screwed up by a nut.

Fig. 27.



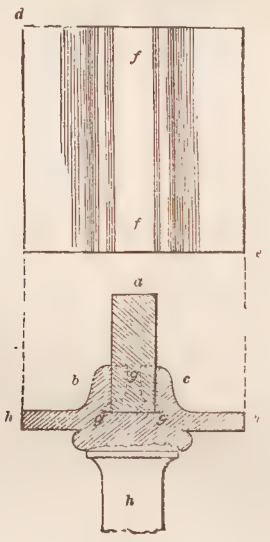
Cap in Plan and Elevation of Iron Column.

Fig. 28.



Upper termination of Iron Column.

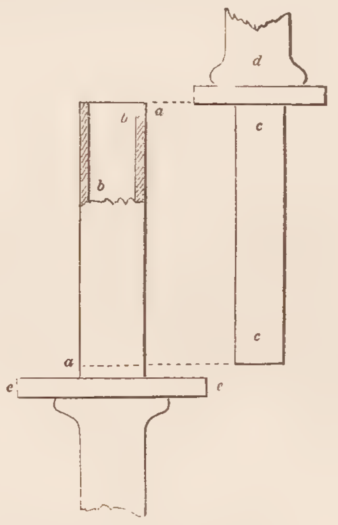
Fig. 29.



Junction of Wood Beam with Cap of Iron Column.

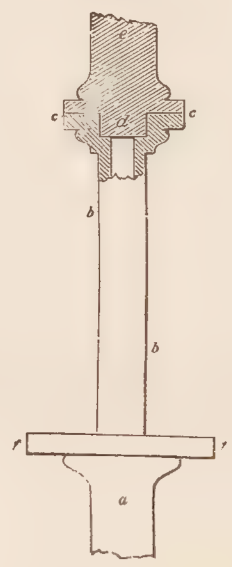
44. Where the building in which the columns are used is two storeyed, the upper column is finished in some cases as at *d e e*, fig. 30, the part *e e* of upper column passing into the hollow *b b* of the collar *a a* of the lower column. The beam in this case is terminated with a round part which embraces the collar *a a*, the lower flange of beam resting on the flange of cap *c c* of lower column. In other cases the upper column is finished at base as shown at *e e e*, fig. 31, the collar *d* passing into a recess made in the upper part *b b* of the lower column *a*. The beam in this case also embraces the part *b*, the lower flange resting on the flange *f f* of the cap of lower column.

Fig. 30.



Junction of two Iron Columns, Upper and Lower.

Fig. 31.



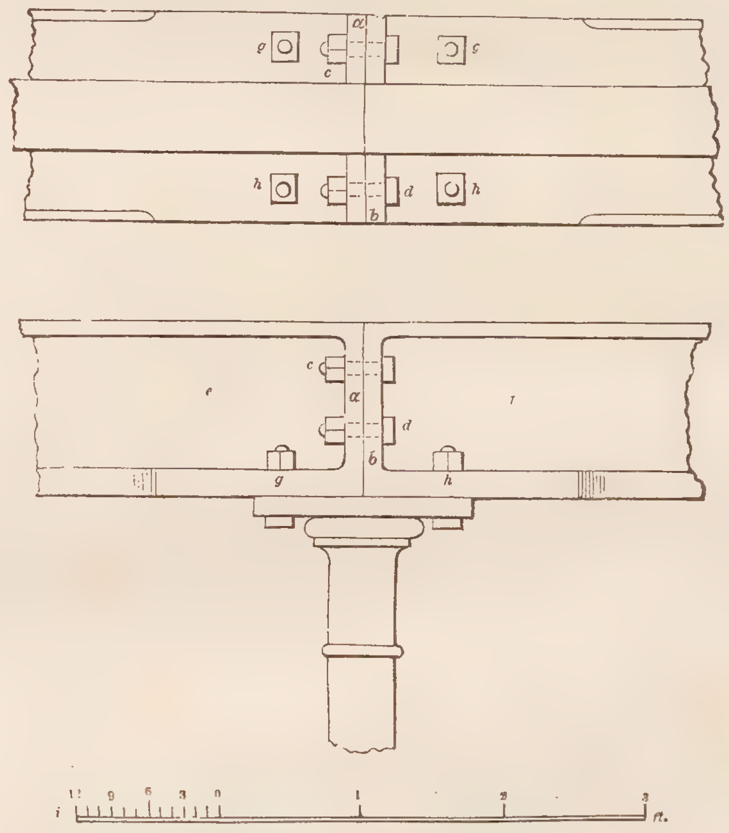
Junction of Iron Columns, Upper and Lower.

45. *Iron Beams.*—Fig. 32 shows the method of joining iron beams to the top of columns, where the beams and columns are in a line, as

————o————o————o————o————

The straight lines representing the beams, the dots the columns. In fig. 32 the beams are finished at the end with flanges *a b*, through which screw-bolts are passed, and tightened up with the nuts *c d*. In the plan above, *g g*, *h h*, show the nuts and bolt ends by which the lower flanges of the beams are connected to the upper flange of the cap of column; *e f* are the central ribs of the beams.

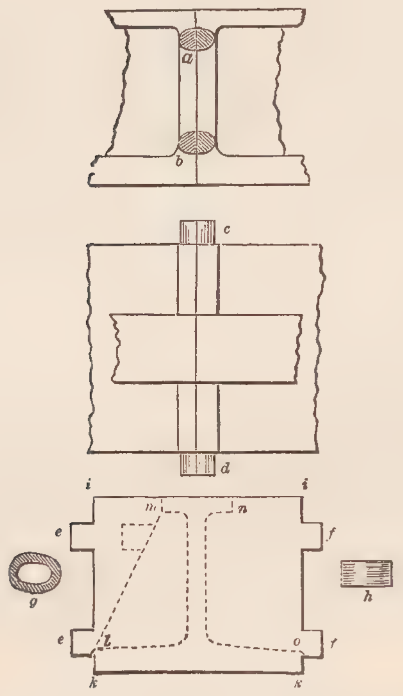
Fig. 32.



Plan and Elevation, showing mode of joining two Iron Beams.

46. In place of bolting the beams together, projecting horns or snugs are cast on the outer edges of the flanges, as *a b* in the side elevation of a beam, fig. 33, *c d* in plan, and *e f* in end elevation. When the ends of the two beams are placed in juxtaposition on the caps of the columns, the flat faces of the horns or snugs come together and form elliptical-shaped parts, as *a b* in fig. 33. These are embraced and kept together by rings, one of which is shown in sectional plan at *g* in fig. 33, and in elevation at *h*. These are driven tightly over the snugs. In the end elevation of beam in fig. 33, the dotted lines *l m n o* indicate the section of the beam; *k k i i* the outline of the outer flanges. In place of making this oblong or square, it may be made to slope, as from *l* to *m*.

Fig. 33.

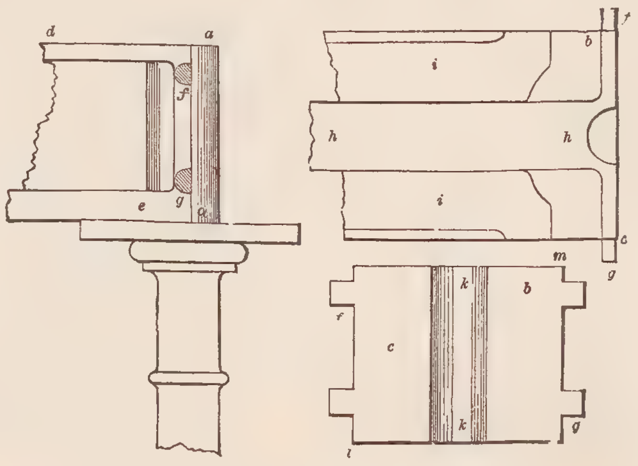


Joining of Iron Beams with Projecting Snugs.

47. These two methods of joining the ends of beams on the caps of columns are also applicable to the junction of the beams which are supported by and cross a transverse wall, the direction of which is at right angles to the line of direction of beams.

48. Where the columns are terminated by circular uprights, as *a a*, fig. 28, or *a a*, fig. 34, the ends of the beams should be terminated with a circular hollow, *k k*, in the end elevation of beam, fig. 34, which embraces the circular part *a a* of cap of column. Flanges *b c*, side elevation, fig. 34, are provided, which, when the two beams are placed together, are held in place by rings driven over the projecting horns *f g*. In the elevation, fig. 34, one of the beams, as *e d*, *f g*, is shown in its place.

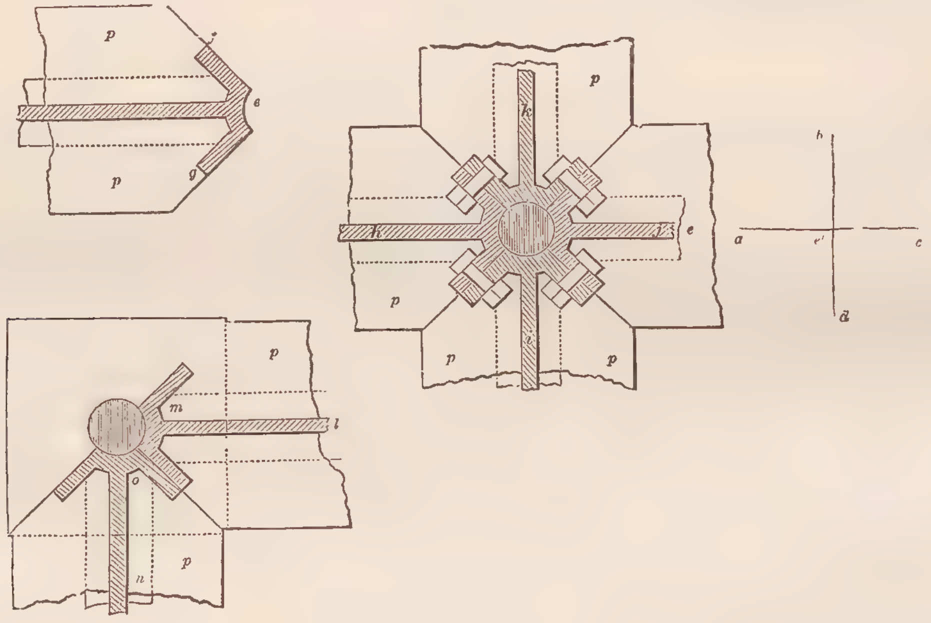
Fig. 34.



Junction of Iron Beam at top of column.

49. In cases where four beams meet, as at *b d*, *a c*, fig. 35, the ends of each beam may be formed as shown *e f g*, *p p* showing the lower flange of beam, the part *e* embracing the central part of cap of column. The sections in fig. 35 are taken at a line a little below the upper flanges of the beams, these upper flanges being represented by dotted lines. In fig. 35, *h*, *i*, *j*, *k*, are the central ribs of the four beams; *p p p e* the bottom flanges. The whole may be secured by bolts and nuts as shown, or by horns, as in fig. 34. In fig. 35, *l m*, *n o*, are the central ribs of two beams meeting at right angles, of which *p p* are the flanges.

Fig. 35.

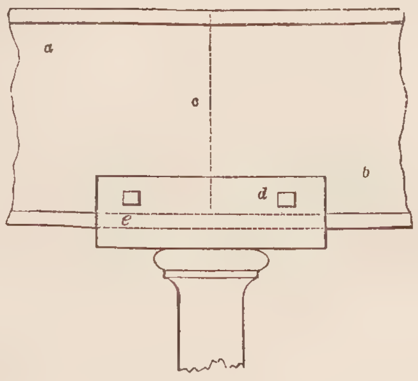


Junction of four Iron Beams.

50. Wrought-iron beams, when laid in line, can be secured in shoes formed in the caps of columns, as shown by dotted lines *g g* in fig. 29, and in side elevation in fig. 36, in which *a b* are parts of the two beams meeting in the central line *c*; *d e* the bolts passing through the shoe corresponding to *b c* in end elevation in fig. 29; or, in place of adopting this method, the two beams, as *a b*, fig. 37, may meet end to end at the dotted line *c*, and be secured together by means similar to what, in railway construction, is termed the "fish joint," by rivetting plates of iron, as *d e*, on each side of the central flanges of the beams.

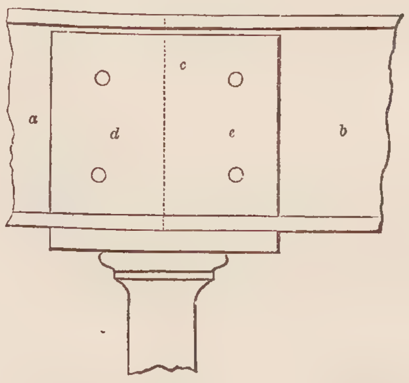
51. Where transverse beams, or binders, are made to cross from the main longitudinal beams for the purpose of support-

Fig. 36.



Side elevation of Fig. 29.

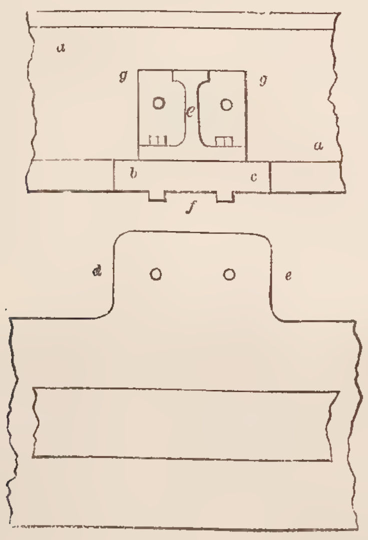
Fig. 37.



Junction of two wrought-iron Beams.

ing the flooring-joists, and which transverse beams are of smaller section than the main beams, they are connected with the main beams by the method shown in fig. 38; where *a a*

Fig. 38.

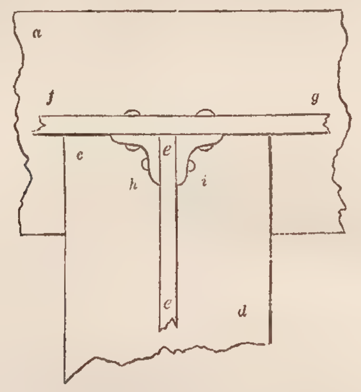


Junction of Cross Girder with Beam.

represents the main beam, provided at the bottom flange with a projecting flange, or table *b c*, shown in plan at *d e*. On this the lower flange of the transverse beam, or binder *e*, rests, and to which it is secured by bolts and nuts *f*. For further security, the inner extremity of the binder *e* may be cast with a square flange *g g*, which abuts against, and is secured to, the central rib of the main beam *a a* by bolts and nuts.

52. Where wrought-iron binders are connected to wrought-iron beams, the joining may be made as in fig. 39; where *a b*

Fig. 39.

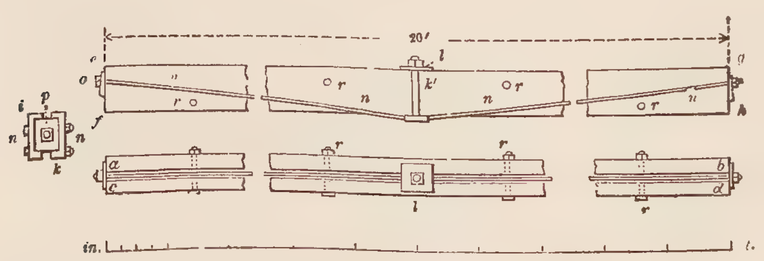


Junction of wrought-iron Beams at right angles.

represents the lower flange of main beam, *c d* that of binder, *e e* the rib—the section being taken at a line a little below the level of the upper flange, which is not seen in the drawing—or central part of the binder; *f g* the rib of the main beam. The end of the binder *c d* is made to abut against the central rib *f g* of the main beam, and the two are secured together by the angle irons *h i*, rivetted to the ribs of beam *f g* and binder *e e*. In the plates accompanying the essays of this work, abundant examples of iron construction will be found.

53. *Composite Beams.—Wooden Beams strengthened by Iron.*—In some cases, where wood is used for beams, it is difficult to obtain them of sufficient scantling or dimensions for the degree of strength required. It is usual in these cases to cut the beam up longitudinally, in the direction of its greatest depth, into two parts of equal dimensions. Each of these parts, as *a b*, or *c d*, fig. 40, is termed a "flitch," and the two

Fig. 40.

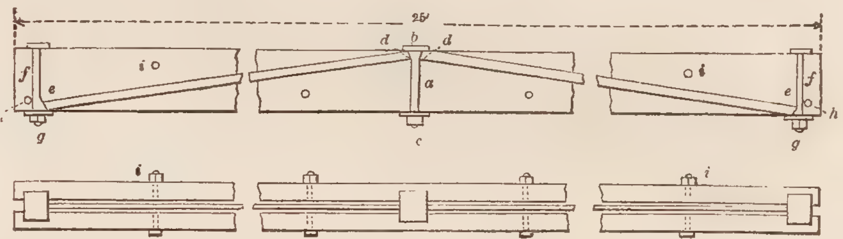


Trussed Beam with Tension Rod.

flitches are joined together by means now to be described, and are, when so joined, termed a "trussed beam." In fig. 40, *e f g h* shows a side elevation of one flitch; *a b*, *c d*, plan of two, and *i k* end elevation of two flitches. A stud *k* is placed between the two in the centre of their length, and screwed tight up, pressing against the plate *l* resting on the upper surfaces of the beams. The lower part of the stud is also provided with a plate, which presses upon the lower surfaces of the two flitches, and is terminated outside this plate by a part with a groove on its lower edge. Round this groove the iron rod *n n* is passed, and the ends of which are led upwards and passed through apertures in plates of iron, one of which is shown at *p* in the end elevation in fig. 40, and screwed tightly up by the nuts *o o*. The two flitches are further secured by bolts and nuts placed at different parts, as *r r*.

54, Fig. 41 illustrates a "trussed beam" on what is called

Fig. 41.

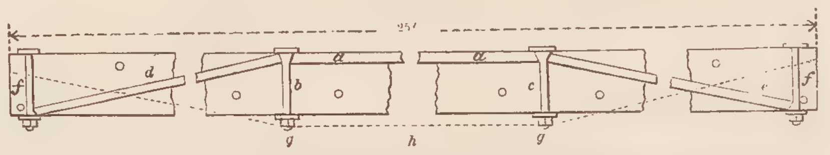


King-post form of Trussed Beam or Girder.

the "king post" principle. The central stud is at *a*, the head *b* is provided at each side with angular abutting parts, against which the studs or braces *d d* abut. The lower ends of these, as *e e*, abut against the end studs *f f*, at the back of which bolts *h h* are placed to keep them in place when the pressure of the struts *d d e e* comes on the studs *f f*; *i i* are bolts securing the flitches together. The stud *a* is tightened up by the nut *c*, and the studs *f f* by the screw nuts *g g*.

55. Fig. 42 illustrates a trussed beam on the "queen post"

Fig. 42.

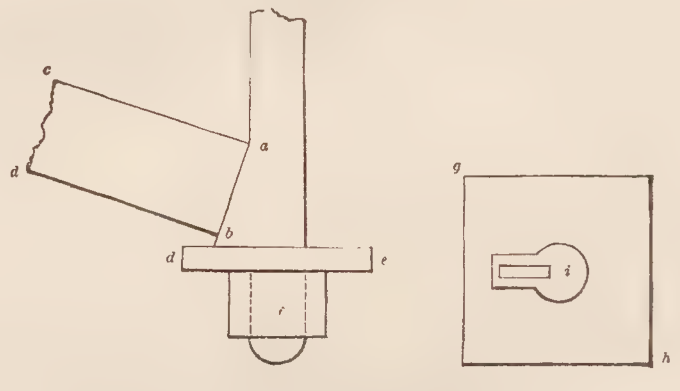


Queen-post form of Trussed Beam.

principle. In this a straining piece, *a a*, is placed between, and abuts upon the upper parts of two studs *b c*, tightened up by the nuts *g g*. The side struts butt at their lower ends on the studs *f f*.

56. In trussing beams with struts, as in figs. 41 and 42, it is necessary to be careful in placing the butting or bearing surface *a b*, fig. 43, of the stud exactly at right angles to the line of

Fig. 43.

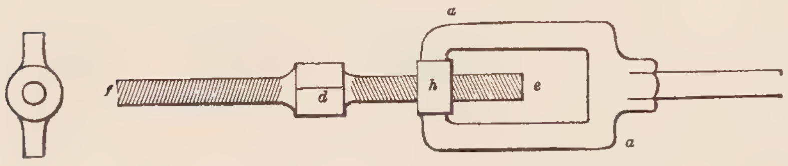


Elevation and Plan of Iron Stud for Trussed Beam in Fig. 42.

strut *a b d c*, so that when the strut is in its place, the line *a b* shall be at right angles to the line *b d*; *d e* is the lower plate of stud, which is tightened up against the lower edges of the flitches by the nut *f*; *g h* shows the plan of stud, *i* being the groove in the butting surface in which the end of the strut *a b c d* is placed.

57. In fig. 42 the dotted line *f g*, *h g f*, represents the position of a wrought-iron tension-rod, used after the same fashion as in fig. 40, with this difference, that the rod passes over two points, *g g*, in place of one, *k*, in fig. 40. Fig. 44 shows a method of tightening up the rod at the central point *h*, fig. 42. The rod *f g*, *g f*, fig. 42, is divided into two parts, *f g h*. The end of *h* being finished, as illustrated in fig. 44, the end elevation of the part *h*, fig. 44, being shown at the left hand side of same figure. The aperture shown in this is screwed to receive one end, *e*, of a bolt *d*. The ends *e f* are screwed with right and left hand threads, so that when the bolt *e f* is turned by the head *d*, the two parts *a a*—one of which is connected with the end *f*—are brought closer together, and the tension-rod tightened as desired, so as to give the flitches the necessary "camber." By this term is meant the convex curve, which the upper part of a trussed beam assumes when the two ends are brought closer together by tightening up the tension-rod.

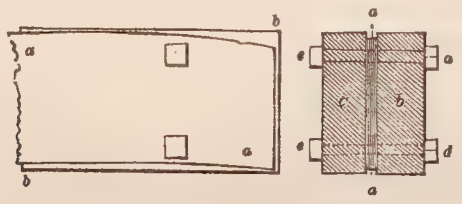
Fig. 44.



Tightening-link of Tension-Rod of Trussed Beam.

58. The two flitches of a beam are sometimes strengthened by having a "flitch," *a a*, fig. 45, of wrought or plate iron placed between them, and secured together by bolts *e d*; in the end section, *a a* the "flitch" of iron; *c b* the two beams.

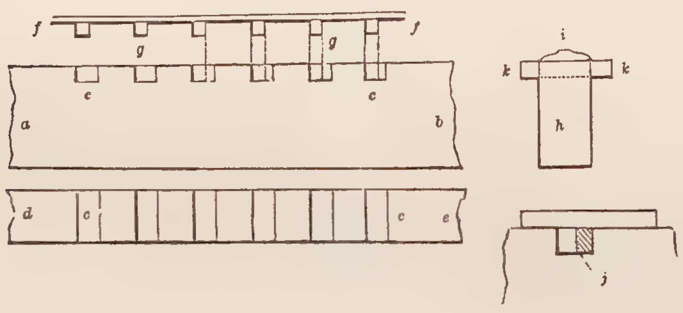
Fig 45.



Iron Flitch for strengthening Beams.

59. Mr. Coombs, of 17 Union Street, London (Borough), has invented a simple mode of trussing wooden beams, as illustrated in fig. 46. *a b* is a longitudinal section. *d e* a plan of top of beam. In the upper side a series of notches *c c* is cut; a plate of iron, *f f* (cast), with a rib *i* running along its whole length, is provided with a series of projecting parts or snugs *g g*; these pass into the notches *c c* in beam. These notches are, however, considerably wider than the projecting parts *g g*, as shown at *j*, so that space is allowed to drive hard up a series of oak wedges *k k*. By the adjustment of the distance to which these wedges are driven up, any degree of camber can be given to the beam. This method seems peculiarly simple and applicable in a great many cases where it would be expensive to adopt any of the methods we have already illustrated. Moreover, it can be adapted with facility to strengthen weak beams *which are already in place*, no removal being necessary.

Fig. 46.



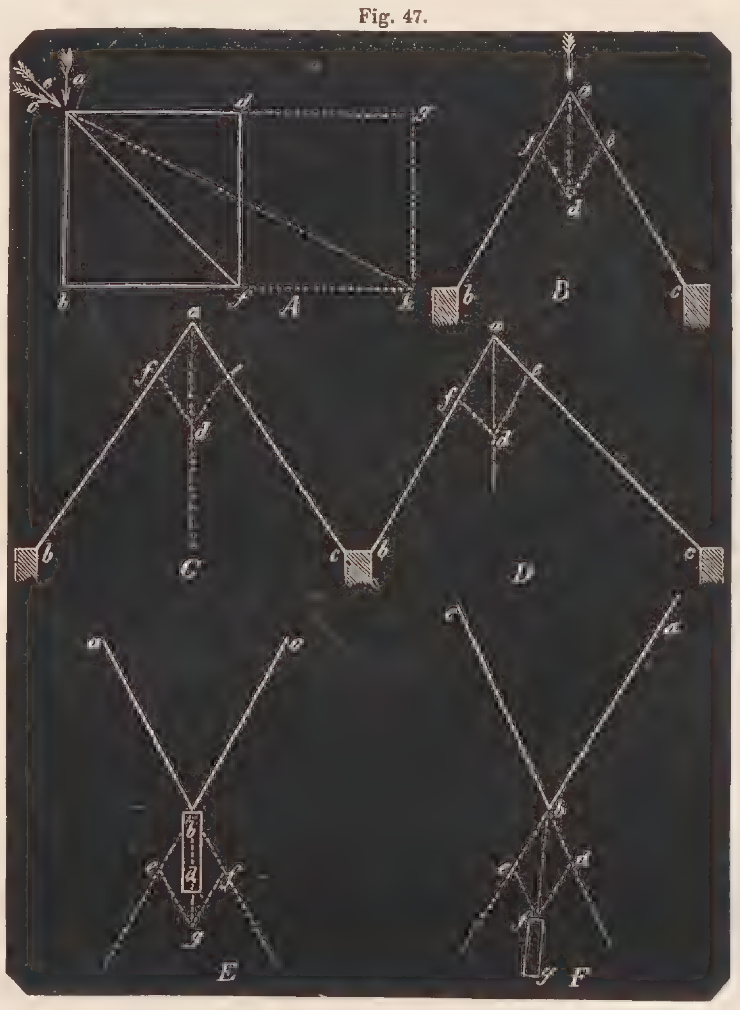
Coombs's Trussed Beam.

60. *Inclined Beams—Frame-work.*—As nearly all frame-work, roofs, partitions, bridges, &c., are composed of inclined beams disposed according to certain arrangements, it is essential for the constructor to know in what *direction* the pressure is applied to these beams, what the *amount* of that pressure is, and the *kind or nature* of the pressure, whether compressile or tensile. How these various points can be ascertained we now propose to illustrate.

61. In order to obtain a correct knowledge of all these points, it will be necessary to understand what is meant by the two phrases, "the composition of forces" and "the resolution of forces," for upon a right understanding of these depends all the problems of frame-work.

62. Suppose a ball, represented by the arrow *a*, fig. 47, diagram A, to receive an impulse in the direction *a b*, calculated to send it on to the point *b*, and again, suppose a ball, represented by the arrow *c*, receives an impulse calculated to carry it in the direction of *c d*, and to the point *d*, *c d* being equal in distance to *a b*, then each ball would travel its appointed distance; but if the ball was to receive at the same instant two impulses as above, it would travel neither in the direction of the line *a b* or *c d*, but it would take a line which may be called the union of the two directions, namely, in the direction of the diagonal of the square, namely *a f*, just as if the ball had received an impetus in the direction of the arrow *e* calculated to carry it on the point *f*. But suppose the impulse given to the ball in the direction of *c d* or to *g* was twice the force or intensity of that calculated to send it in the direction *a b*, then the ball would follow the direction of the diagonal *a h*.

Fig. 47.



Diagrams illustrating Composition and Resolution of Forces.

63. In both cases the diagonal, *a f*, *a g*, is called the *resultant* of the two component forces, *a b*, *c d*, or *a b*, *c g*.

64. The operation which has for result the finding of two forces acting in different directions, as *a b*, *a g*, which shall be equivalent to one acting in the direction of *a h*, is called the *resolution of forces;* while that which aims at finding a single pressure, as *a h*, which shall be equivalent to two, as *a b*, *a g*, is termed the *composition of forces.* How these two operations are made to be useful in the calculation of frame-work we now propose to show.

65. The pressure on any vertical column, as *a*, fig. 1, by the weight *b* pressing in the direction of the arrow *c*, is measured by the weight merely of *b*; but in the case of in-

clined beams, as the pressure is dependent upon the angle of inclination, another and more difficult method is required to ascertain it. And here is shown the utility of the resolution of forces. Let *a b*, *a c*, diagram B, fig. 47, be two inclined beams, resting together at the apex *a*, and pressing on the walls *b c*. Suppose a weight to press vertically on *a*, and this weight to be equivalent to 20 tons, then drop a perpendicular to the point *d*, and make the distance *a d* equal to 20 parts, taken from any scale of equal parts, as of eighths, sixteenths of an inch, or the like. Then from the point *d* draw a line parallel to the line *a b*, cutting *a c* in the point *e*. Next, from the same scale of equal parts as *a d* was measured from, take the distance *a e*, and the amount will be the pressure which the weight, acting in the direction *a*, imparts to the inclined beam *a c*. But as the beams *a b*, *a c*, are of equal inclination, the pressure sustained by *a b* is equal to *a c*, so that the two pressures together are greater than the single pressure acting in the direction *a d*. That the *united* pressure of two inclined beams increases as the angle of inclination of the beams increases, will be illustrated by projecting a diagram, as in fig. 47 at diagram C. Let *a b*, *a c*, be the two beams, and *a* the weight pressing downwards, equal in amount to *a* in diagram B; drop a perpendicular *a d*; make the distance equal to 20, as in diagram B; from *b* draw parallel to *a b* the line *d e*; the distance *a e* in the scale of equal parts represents the pressure on the beam *a c*, which will be found to be equal to $3\frac{1}{2}$, a greater pressure than on *a c* in diagram B. This greater pressure, as the beams are of greater inclination, is still more clearly illustrated by projecting a diagram as at D in fig. 47, in which the beam *a b* is of less inclination than *a c*. By proceeding as in diagram B, the pressure on the beam *a c* will be greater than that on *a b*. From this will be deduced the important truth in frame-work, that the greater the inclination of beams the greater is the pressure; and from this again is deducible, that the nearer the perpendicular a beam approaches, the stronger it is; the horizontal position is always the weakest. These problems are illustrative of the "resolution of forces," in which we find two forces as *a e*, *a f*, diagrams B, C, and D, fig. 47, which are equivalent to, or rather, which balance or counteract another, as *a d*. We now proceed to illustrate the converse of this, or the "composition of forces," which has for aim the finding of one force which shall balance or counteract two other forces.

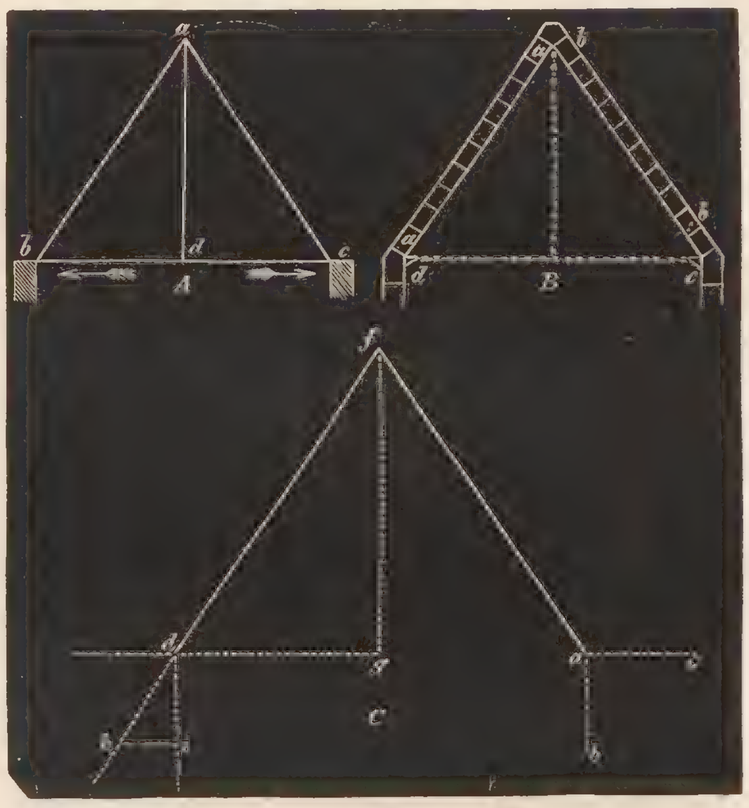
66. Let *a b*, *b c*, diagram E, fig. 47, be two inclined beams, abutting on the vertical beam *d*, and each pressing upon the beam *d* with a force of 15 tons—the pressure sustained by the upright beam *d* is found as follows:—Coincident with the direction of beams, as *a b*, *c b*, draw or extend the lines to *b e*, *b f*, and make each of these equal to 15 from a scale of equal parts. From the point *e* draw a line *e g* parallel to *a b f*, and from *f*, *f g* parallel to *c b e*, the two meeting in *g*. From *b* draw the diagonal *b g*; this being measured will give the pressure sustained by the beam *b d*, and the line *b d g* the direction in which the beam *b d* should be placed in which it will best resist the pressure of the two beams.

67. But in cases where the angle of the two beams, *a b*, *b c*, is not equal, as in E, fig. 47, but unequal, as *a b*, *b c*, diagram F, fig. 47; the direction of beam to resist the pressure of these will be different from *b d* in diagram E, fig. 47. To find the direction, and also the pressure which it sustains, proceed as follows:—Let *a b* be the direction of a beam which is pressed with a pressure of 15 tons, and *b c* that of another pressed with 10 tons. Coincident with the line *a b* draw *b e*, and make it equal to 10 from a scale of equal parts. Next draw a line coincident with *a b*, as *b e*, and make *b e* equal to 15 from the same scale of equal parts. Draw from *e* parallel to *b d*, and from *d* parallel to *b e*, lines meeting in *f*. Draw the diagonal *b f*; this will give the direction in which a post *g* should be placed to resist the pressure of the two inclined beams *a b*, *b c*; the amount of pressure which this beam sustains being ascertained by taking the distance *b f* from the scale of equal parts used to measure *b c*, *b d*.

68. What in framing is called a *truss*, is the disposition of inclined beams forming a triangle, as in diagram A, fig. 48. In a roof truss, the inclined beams, as *a b*, *a c*, are termed the "rafters;" *a b c* the "tie beam;" *d a* the "king-post." This triangular truss is the strongest possible way in which to arrange materials so as to resist pressure. This resistance, indeed, is only limited by the strength of the materials of which the truss is composed, and of the joints which retain the whole together.

69. In the truss, Diagram A, fig. 48, the rafters, or inclined beams, *a b*, *a c*, are only subjected to *compression*. This is illustrated in diagram B, fig. 48, in which the rafters are supposed to be made up of a series of blocks of wood or stone, *a a*, *b b*, and laid simply in juxtaposition with each other. These will resist any vertical pressure.

Fig. 48.



Diagrams illustrating Trusses.

70. Again, the pressure sustained by the king-post *a d*, and the tie-beam *b c*, diagram A, fig. 48, is entirely tensile, and the two may be made out of chains, as the tie-chain *d e*, diagram B, fig. 48, and the king-chain *f*.

71. The office of the "tie-beam," represented by the line *b c*, diagram A, fig. 48, is to counteract the tendency which the beams *a b*, *a c*, have to push the walls out in the direction of the arrows. The pressure of the inclined beams is oblique, but at the foot of each beam the pressure is of two kinds, to drop or fall down in the direction of *a b*, diagram C, fig. 48, and to slide outwards in the direction of *a c*. The use of a tie-beam, represented by the line *a d*, is to counteract the sliding out tendency *a c*, the vertical tendency *a b* being obviously resisted by the wall *e*, on which the beam rests.

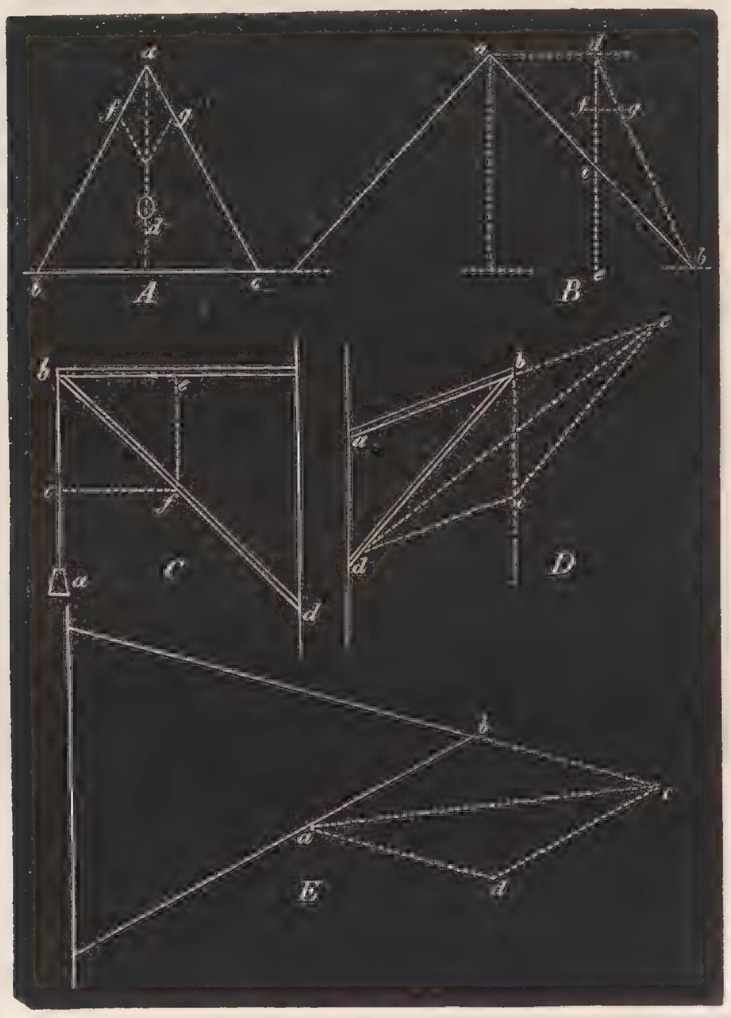
72. It is of importance, then, to know the amount of pressure sustained by the foot of the inclined beam tending to thrust it out in the direction of *a c*, diagram C, fig. 48, as also the vertical pressure on the wall or column *a b*. Drop from the apex *f* of the triangle a perpendicular line *f g*, and draw from foot of beam *d* a line *d g* at right angles to this. Coincident with the line *f d* of beam, draw the line *d h*, and make this equal to the vertical pressure sustained by the beam *f d*. From *h*, parallel to *d g*, draw a line *h i*, and from *d* drop a perpendicular *d i*, cutting *h i* in *i*; then the distance *h i* is equal to the pressure in the horizontal direction, tending to thrust it out in the direction of *a c*, and the distance *d i* equal to the vertical pressure in the direction *a b*.

73. If it is required to estimate the pressure sustained by

two inclined beams, *a b*, *a c*, diagram A, fig. 49, resting on the ground, and subjected to a pressure, as the pressure exerted by the weight *a d*, as in the instance of guys for lifting weights. Thus, from *a* measure to *e*, a distance corresponding to the weight represented by *d*; from *e*, parallel to *a b*, draw the line *e g*, and *e f* parallel to *a c*. The distance, *a f*, *a g*, will give the pressure on each beam.

74. In the case of a roof-truss, as diagram A, fig. 48, as the weight is not exerted through the beams in the direction of their length, as *a b* or *a c*, but is spread over their whole surface from top to bottom by the roof materials, as slates, &c., resting on them, it is necessary to know the thrust or pressure on the beams at the wall. Let *a b*, diagram B, fig 49, be an inclined beam, and let *c* represent the centre of the beam; through this point *c* drop a perpendicular line *c d e*. From the apex *a* of the roof draw a line *a d* at right angles to *c d e*. Draw a line *d b*, this represents the line of direction of the thrust of the beam *a b* on the wall. The next point is to ascertain the amount of this pressure on the wall. Suppose the estimated weight of the roof materials resting on the beam *a b* to be represented by 12, then from the point *d* in the line *d e* measure off from a scale of equal parts the distance *d f*; and at right angles to *d e* from *f* draw the line *f g*. This distance *f g* represents the amount of pressure or outward thrust exercised by the beam *a b* on the wall.

Fig. 49.



Diagrams illustrating methods of finding pressure in Beams.

75. The mode of ascertaining the amount of the pressure exercised by the weight *a*, diagram C, fig. 49, and the best position for the diagonal strut *b d*, is as follows:—Let the weight of *a* be represented by 12; set off from *b* to *c*, a distance equal to 12; parallel to *b c* draw a line *e f*, also equal to *e f*; join *c f*; draw the diagonal *b f*; *b f d* is the line of the strut, and *b f* the amount taken from the scale of the pressure sustained by the strut *b d*.

76. The same method is adopted in finding the pressure upon a strut *b d*, diagram D, fig. 49, to support a beam *a b* projecting from a wall, and which supports a weight *c*. Drop a perpendicular *b c*, and make *b c* equal to the weight or pressure upon *a b*, say 15; from *c* parallel to *a b* draw a line *c d*; and from *c* a line *c e* parallel to *d b*, meeting *a b* produced in *e*. Draw the diagonal *e d*, which represents the pressure upon the strut *b d*.

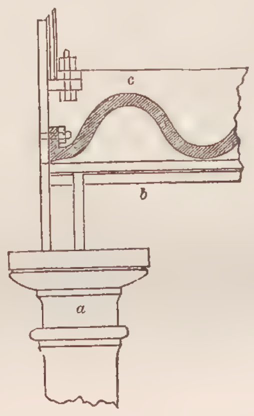
77. In truss and frame-work the parts which are subjected to compression are called "struts," those to tension "ties." To ascertain whether the different parts of a truss act as "struts" or "ties," the following rule may be used:—"Construct the parallelogram of forces according to the pressure exerted by the weight *a b*, *c d* (diagram E, fig. 49); then if one side of the parallelogram, as *d c*, parallel to one of the pieces, as *a*, cuts a line produced from the other piece *b*, that other piece acts as a "tie;" if the line, as *d a*, parallel to *one* piece *b*, cuts the other piece *a b*, the piece *a b* acts as a strut. Thus, where the line cuts the *piece itself*, that piece acts as a strut; if it only cuts a line *produced from the piece*, that piece acts as a tie."

78. Illustrations of Roofs of Iron and Timber will be found in the plates accompanying the letter-press of this work.

79. It will serve some useful purpose if we here give brief descriptions of recent improvements in iron construction, and of methods of rendering that material more economical by giving it forms, or placing it in positions by which the maximum strength will be obtained with the minimum weight of metal.

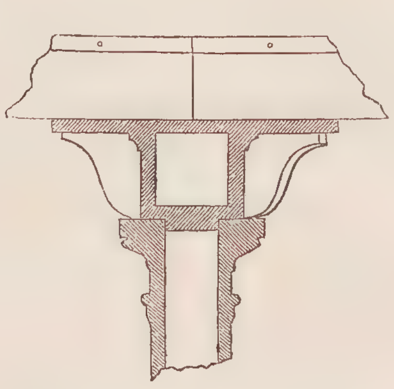
80. A very common method of attaining the object named above, is by corrugating the iron, that is, throwing the surface into a series of small arches, as shown at *c*, in fig. 50. Corrugated iron has been largely used of late years, and for a variety of purposes. Mr. Barlow, the well-known civil engineer, introduced it into the construction of bridges, for which he finds it well adapted. Fig. 50 shows part of the bridge construction, being a cross section, *a* the cast-iron pillar, *b* the beams on which the ends of the corrugated plates *c*, rest. Fig. 51 is a side view.

Fig. 50.



Corrugated Iron Bridge-Section.

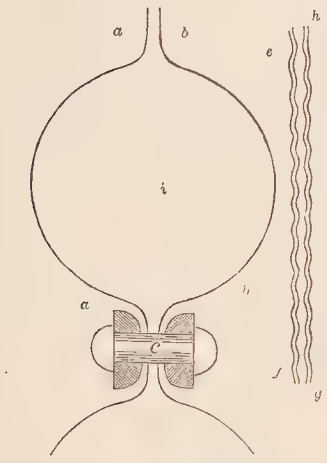
Fig. 51.



Corrugated Iron Bridge—Side Elevation.

81. Mr. R. Davison, C.E., of 8 London Street, City, London, has patented an ingenious adaptation of the corrugated principle, by which greatly increased strength is obtained. This is illustrated in fig. 52, in which the plates *a b* are joined by the rivet *c*. For walls of sheds, roofs of buildings, this form presents many advantages, not the least of which is the establishment of a series of hollow chambers, as *i*; these,

Fig. 52.

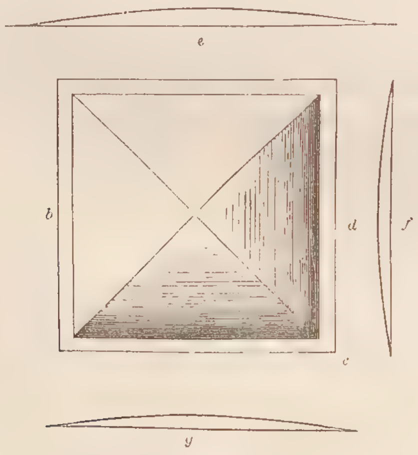


Davison's Double Corrugated Plates.

containing air, will prevent the overheating of the air within the walls or below the roof covering in summer, and undue cooling in winter. The plates *e f*, *g h*, show the disposition of the plates forming the outside walls of a building, or of a roof covering.

82. Having explained the method by which sheets of metal are greatly strengthened by corrugating their surfaces, it is to be noted that although this gives great stiffness transversely, or in the line of corrugations, these do not give stiffness to the metal in a line across the corrugations. A method of treating sheets of metal in such a way that it shall be equally strong in all directions is therefore a point of great importance in construction. We believe this to be attained in a remarkable degree by Mr. Mallet's "buckled plates." This name is given to any plate of iron, or other metal, and of whatever shape, of which the surface has been curved or arched, this arch having a very small rise, or curvature, springing from the edges of the plate in all directions towards the centre. Fig. 53 gives an illustration of a buckled plate. A section of the plate *a b c d*, in the line *b d*, is shown at *f*, and a section in the line *a c* at *e*.

Fig. 53.

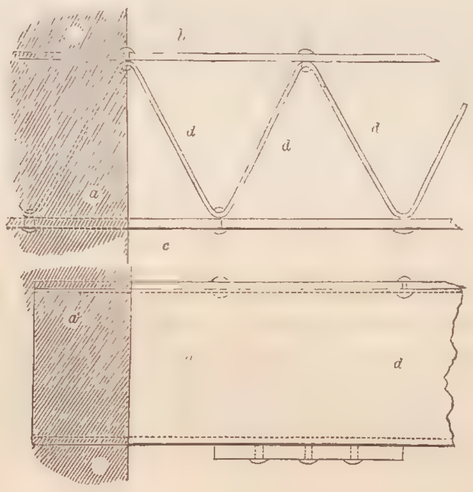


Mallet's Buckled Plate.

83. As will be seen from the above illustration, a transverse section of a plate in any direction presents a curved line. A buckled plate, therefore, is in reality a very thin and flat polygonal dome or groined arch. The thrusts of any load placed upon the upper surface, or extrados, in the direction of any two opposite sides, are sustained by the tensions of the outer portions of the adjacent sides of the plates. The flat margin of the plate, as shown in the illustration, is termed the "fillet." A buckled plate possesses enormous strength, and is applicable to a vast variety of purposes. A three-foot square plate of ordinary Staffordshire iron, $\frac{1}{4}$ inch thick, with a fillet 2 inches wide, and a rise or curvature of $1\frac{3}{4}$ inch, requires nine tons to cripple it, and this when the edges are supported or rest merely all round; but when the edges, or fillets, are bolted or riveted all round to rigid framing, it takes 18 tons to cripple it. The resistance of a square buckled plate is directly as the thickness, and inversely as the bearing. Applications of it to fire-proof floors and partition roofs will be found described in a succeeding part of this Essay.

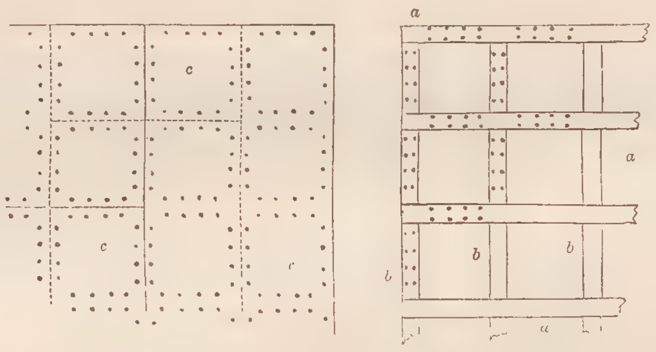
84. In place of corrugating, or buckling plates of iron, Messrs. Tarte & Toovey of Brussels have introduced a method of disposing plates in an angular position. This is illustrated in fig. 54, which is a section and elevation of a floor, or bridge, and which is composed of an "uninterrupted union of equilateral triangles in metallic plates, susceptible of being indefinitely prolonged by means of riveted joints, which attach these plates lengthwise and breadthwise, in order to make all its constituent parts but one and the same piece." The plates *d d d* are bent to angles of about 60°, and the apices meet alternately with the upper and lower plates *b b*, *c c*, to which they are strongly fixed by rivets. The lower illustration in diagram, fig. 54, is a side elevation. This form or disposition of metal plates is best adapted for floors or bridges, the greatest resistance being in the direction of the ridges or apices of the angular plates. Applied to roofs it is light, elegant, and strong. In place of filling in the space between the upper and lower plates, as *b b*, *c c*, in fig. 55, with angular plates, as *d d*, the patentees sometimes fill up the spaces with bars crossing at right angles, as illustrated in fig. 55. The framing in this case is composed of a "lattice of iron bars or bands, *a a*, *b b*, crossed at right angles, and at their intersections they are notched to half their thickness, so as to fit into one another. The frame thus made is placed between two plates—an upper and a lower one—to which it is secured by rivets." The frame is divided into equal spaces, say of from ten to twenty inches square. For a floor capable of bearing $1\frac{1}{2}$ to 2 tons per square yard, the upper and lower plates of sheet-iron should be from $\frac{1}{8}$th to $\frac{3}{16}$ths of an inch in thickness, the width of space between the plates varying from $2\frac{1}{2}$ to 5 inches. In place of having simple flat bars of iron to fill up the spaces between the plates T iron may be used; these should be reversed thus, T ⊥ alternately, crossed at right angles, notched at their intersections, and the upper and lower plates secured to the flanges by screw bolts or rivets. The illustration to the left of the diagram in fig. 55 shows the disposition of the rivets or bolts, the full line showing the upper, the dotted line the under plate. In fig. 56 we illustrate a floor and ceiling constructed on this prin-

Fig. 54.



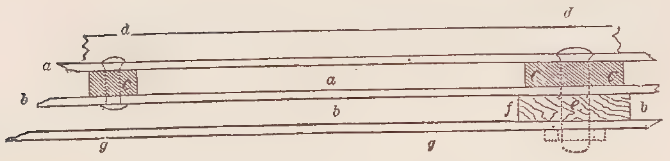
Angular Disposition of Iron Plates.

Fig. 55.



Rectangular Disposition of Iron Bars for Floors.

Fig. 55.



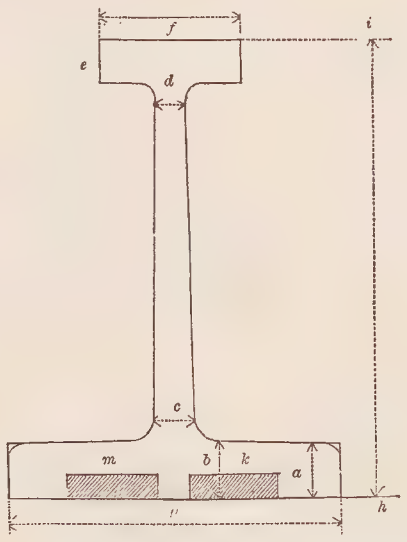
Section of Floor on Principle illustrated in Fig. 54.

ciple, in which *a a*, *b b*, are the upper and lower plates, *c c* the iron bars or bands, *d d* the flooring boards. The plastering *g g* is supported by laths nailed to the butts *f*, which are secured to the bars *c c* by screw bolts, or by wood screws traversing the iron plates. The patentees of these two methods of using iron to obtain great strength and lightness, give in their specification (No. 1040, 1860), the following table, which may be useful, and demonstrates the "influence of the space between the two plates upon their supporting power, and on the other hand, the reduction which can be made in the distance of the two plates by increasing their thickness without changing the resistance to pressure."

Square Floor. Length of Side.		Weight borne per Square Yard.				Thickness of upper and lower Plates.	Distance between the Plates.	
Feet.	Inches.	Tons.	Cwts.	Qrs.	Lbs.	Inches.	Feet.	Inches.
6	6	2	3	0	8	⅛	...	½
13	1	0	10	3	2	⅛	...	½
		1	14	1	24	⅛	...	1⅞
		2	3	0	8	⅛	...	2⅜
19	6	0	10	3	2	⅛	...	1¼
		1	14	1	24	⅛	...	4⅜
		2	3	0	8	⅛	...	5½
		2	3	0	8	$\frac{3}{16}$	...	4
26	3	0	10	3	2	⅛	...	2⅜
		1	14	1	24	⅛	...	8
		1	14	1	24	¼	...	4
		2	3	0	8	⅛	...	10
		2	3	0	8	$\frac{3}{16}$	...	4
32	9	0	10	3	2	⅛	...	4
		1	14	1	24	⅛	1	¼
		1	14	1	24	⅜	...	4
		2	3	0	8	⅛	1	3¾
		2	3	0	8	½	...	4

85. We have already given illustrations of the best section of cast-iron beams; we now give an illustration of the method of combining wrought-iron with cast-iron, as introduced by Mr. Gardner. The principle here adopted is placing bars of wrought-iron in *m k* in the under side of the lower flange of the beam, and which has the effect of greatly strengthening it.

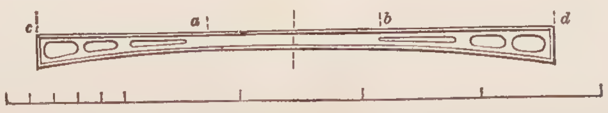
Fig. 56.



Combined Wrought-iron and Cast-iron Beam.

86. Where retaining walls of brick or stone are not used for buildings, but where the roof is supported by pillars or columns, the space between these being filled up with timber, as in the case of sheds, the pillars are placed at considerable distances from each other, as already described, the intermediate rafters of the roof being supported by and fixed to either a wooden trussed beam (see fig. 40), a wrought-iron beam (see fig. 36), or to a cast-iron open girder, as in fig. 57.

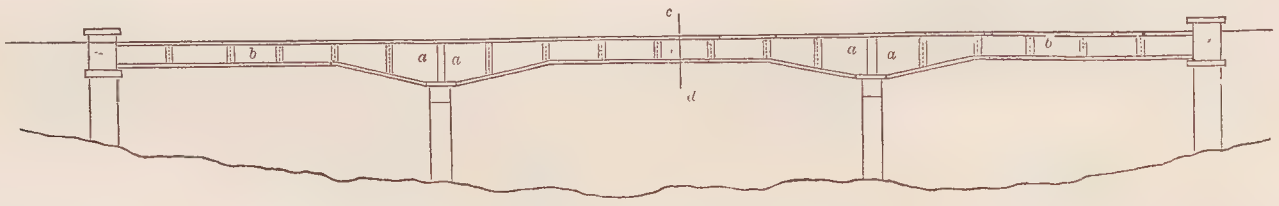
Fig. 57.



Open Cast-iron Girder.

87. We have given elsewhere in this Essay remarks on the best forms of beams as regards their section. Mr. W. H. Barlow has patented (No. 908, 1859), improvements in the longitudinal form, or outline of beams, which we think of importance to give here. The following is Mr. Barlow's description of the principle upon which the form is decided, as illustrated in fig. 58:—

Fig. 58.



Barlow's Form of Iron Beams for Bridges, Flooring, &c.

88. "It will be seen that an intermediate support, applied to a beam, may be regarded as pressing upwards against the under side of the beam, and this pressure of the support gives to the beam an upward flexure, that is to say, it renders it convex on its upper surface and concave on its under surface; near the centre of each span of the beam the flexure is downwards, being produced by the weight of the beam itself, and of the load upon it.

89. "Between the centre of each span and the intermediate support there is a point where there is no flexure, and at this point the strain is less than at any other point in the length of the beam. The upward pressure over the pier, or intermediate supports, acts at a point, or nearly so, while the downward pressure, occasioned by the weight and load, acts over the whole extent of the beam on which such weight and load is distributed; the consequence is, that when a continuous beam is made of equal depth and section throughout, and loaded uniformly all over, the curvature upwards over the point of support is sharper, that is to say, it is of less radius than the curvature downwards in the centre of the span, and the breaking points of such a beam, so loaded, would be at the places over the intermediate supports.

90. "In the construction of continuous beams, or girders of wrought iron, such girders have in some instances been made with an increased section of metal in the flanges at the parts over or near the piers, but retaining the same depth, and in this manner a minor degree of advantage is obtained as regards the economical distribution of metals in the flanges. Now, according to my invention, in constructing beams or girders I increase the depth of the beam or girder over or near the piers or intermediate points of support, by which means I not only obtain greater strength over the piers or intermediate points of support with the same quantity of material in the flanges, but the radius of curvature of the upward flexure is rendered greater, that is to say, the curve is flatter, and the points of contrary flexure are thereby moved nearer to the centre of the span, so that the sectional area of metal in the flanges throughout the centre portion of the beam, between the points of contrary flexure, may be considerably reduced without diminishing the strength of the beam when compared with a beam of equal section or of equal depth throughout, as heretofore constructed.

91. "And it will be seen that in large girders, when the dead weight of the centre portion of the beam is thus reduced, it also relieves in a

proportionate degree the strain over the intermediate pier, so that a great economy of material results from this mode of construction. In constructing beams or girders upon this principle I continually diminish the depth from the maximum depth over the intermediate pier or support to a point at or near the mean position of the point of contrary flexure, which will usually be about half way between the intermediate pier or support and the centre of the span; and from this point I continue the depth of the beam equal, or nearly equal, throughout all the centre portion of such beam; I also make the sectional area of the flanges at and near the piers or intermediate supports, and also at and near the centre of the span proportional, or as nearly so as may be convenient to the maximum strain which would arise in such parts from the weight of the structure itself as well as from the insistent load, or any moving load which it may be intended to carry.

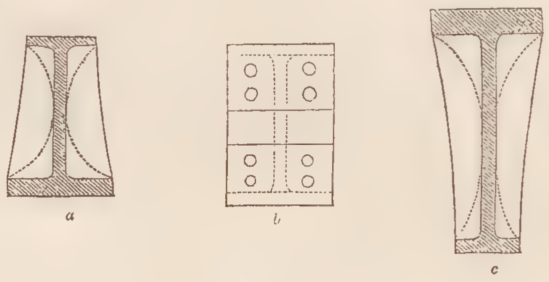
92. "But to those parts which are at or near the points of contrary flexure, I give a sectional area to the flanges greater than is required to resist the strains to which such parts are subjected, for the purpose of obtaining greater stiffness and less deflection when the spans are unequally loaded.

93. "Fig. 58 shows a girder with plated sides suitable for supporting a roadway or platform on its upper flanges; for convenience of doing this the increased depth over the girder is given by lowering the bottom flange in place of raising the upper flange. In constructing girders upon this principle I prefer the following proportions, namely—The depth of the girder over the pier to be 1½ times the depth at the centre. The centre depth to remain equal, as at *b b*, between the points *a a*, being a distance equal to one-half the clear span. From the points *a a* to the piers the depth increases in an arithmetical ratio to the maximum depth at the pier. The sectional area of the flanges at the pier to be 1½ times the sectional area at the centre; and the sectional area at the points *a a* to be ¾ of the sectional area at the centre. The depth of the girder at the centre to be about $\frac{1}{16}$th of the clear span, but may vary from $\frac{1}{12}$th to $\frac{1}{20}$th. To girders of these proportions the following rule for finding the actual section to be given to the different parts apply. In constructing a continuous girder upon this principle it is first necessary to ascertain the approximate weight of the intermediate span, and this for wrought-iron may be done as follows:—Multiply the intended maximum load in tons per foot (both dead load and moving load) by the cube of the span in feet, and use this as a numerator. Then if the girder is to be made with lattice or open work sides, multiply the depth in feet at the centre into the intended maximum strain per inch upon the metal in tons, and by the number 3,600, and from the product deduct the square of the span in feet, use this as a denominator. Divide the numerator by it, and the quotient will be the approximate weight of the girder in feet at the centre by 2,820 times the intended maximum strain upon the metal per inch in tons, and deduct from the product the square of the span in feet. Use this as a denominator, and divide the numerator by it, and the result will be the approximate weight of the girder in tons. The weights thus found are for the clear distance between the supports of one of the intermediate spans. It is next necessary to find the strain on one of the flanges at the centre of the girder; to do this add together the weight of the girder, the dead load, and the maximum moving load, which can come on one span in tons; or multiply the maximum load per foot in tons (both dead and moving load) by the length of one intermediate span in feet for the gross maximum load, and add to it the weight of the girder. Then, to find the section to be given to the flanges at the centre, multiply the total weight in tons thus obtained by the span in feet, and divide the product by 20 times the depth of the girder at the centre in feet, the result will be the strain at the centre in tons. The strain at the centre, divided by the intended per tons per inch, will give the net section at the centre. One and a-half times this quantity will be the sectional area at the piers, and ¾ of the centre section will be the section at *a* and *a*. The sectional area of the intermediate parts will be determined by the usual rules, observing, however, that no part of the flanges is to be made less than ¾ the section of the centre. The above rules applied to three or more contiguous spans, when the terminal spans are ¾ of the centre span, or intermediate span, or thereabouts If the terminal spans are less than $\frac{11}{14}$ths, or more than $\frac{13}{16}$ths, of the intermediate spans, or if the intermediate spans are unequal in magnitude, it is necessary specially to calculate the positions of the points of contrary flexure under the extreme variations of the moving load, and proportion the parts accordingly. . . .

94. "In constructing beams or girders of cast-iron—as this material differs from wrought-iron in its being capable of sustaining a much greater compressive force than tensile strain—it is usual to make the bottom flange of considerably greater area than the top flange. In constructing continuous beams or girders of this material the same system has hitherto been followed. Now, according to my invention, at the points over and near the piers or supports I make the top flange of greater area than the bottom flange to meet the change in the direction of the strain. I also at these points give to the beam a greater area of section than it has at other parts of its length, and also a greater depth. If the continuous beam or girder is of such a length as to have to be cast in more than one piece, I arrange the joints to fall at or near the points of contrary flexure, the length of girder necessary to pass from one point of contrary flexure over a pier or support to the next point of contrary flexure, being always cast in one piece."

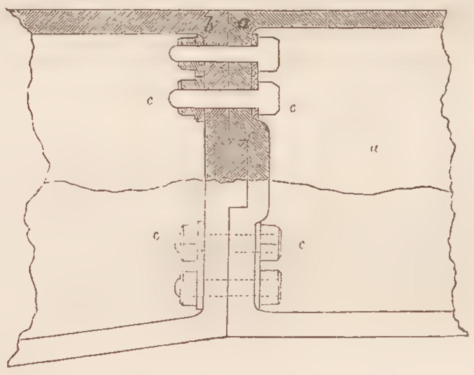
95. In fig. 59 *a* is a section of beam arranged as in fig. 58, taken at the line *c d*, fig. 58; *c* is a section taken at *a a*, fig. 58; and *b* is an end view of one of the portions of the girder. In fig. 60 is a side view of the joint and the parts near it, shown on an enlarged scale; *a a*, *b b*, the two beams, the upper parts of which are shown in section, and the lower in elevation; *c c* the bolts and nuts by which the beams are secured together.

Fig. 59.



Sections (*a c*) and End View (*b*) of Barlow's Iron Beams.

Fig. 60.



Junction of Barlow's Iron Beams.

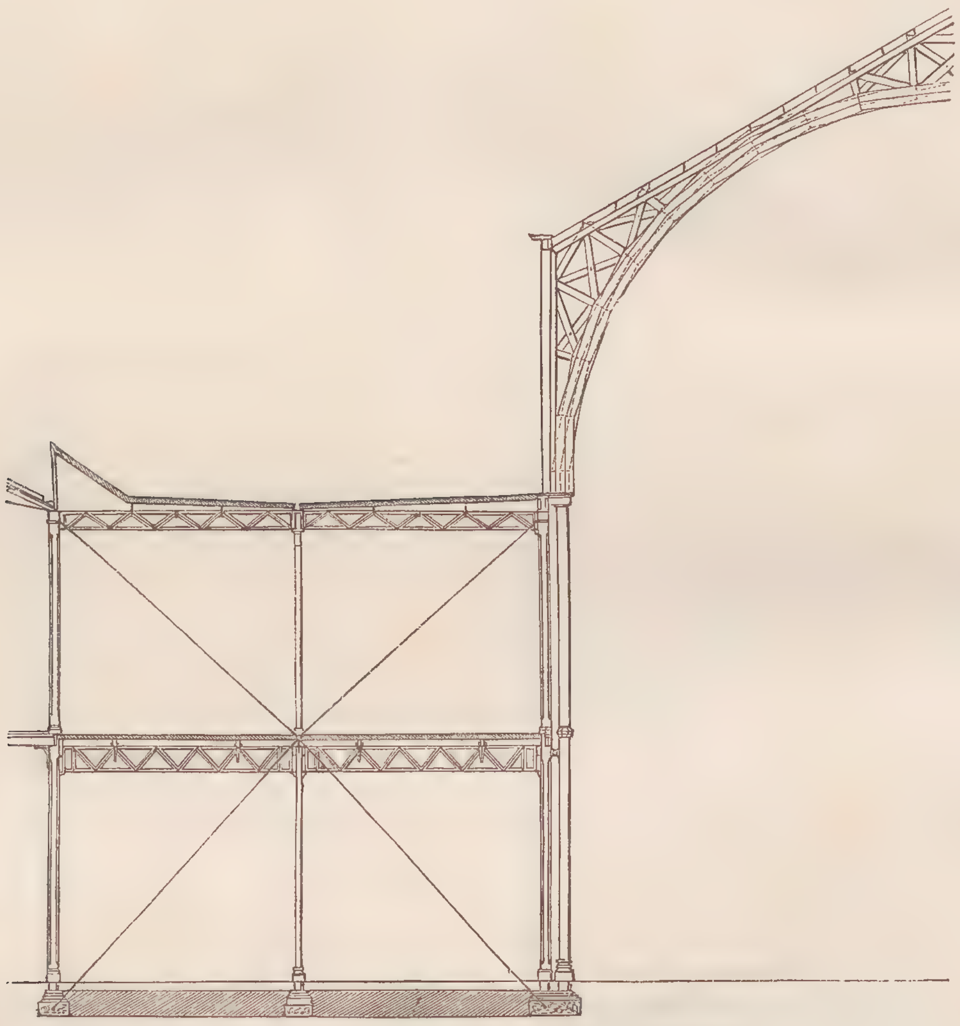
96. *Iron and Timber Construction as exemplified in the Building for the Great Exhibition of* 1862.—It affords us considerable pleasure to be able to present our readers with illustrations and descriptions of the most important parts of this great structure. For the matter of the description we are indebted to an able paper, read by Captain Phillpotts, R.N., before the Society of Arts, London, and the engravings have been courteously and promptly placed at our disposal by Peter Le Neve Foster, Esq., the able secretary of the Society, and to whom our thanks are specially due.

97. Before giving the illustrations it will be necessary to glance briefly at the general plan and arrangements of the building. The ground on which the main building stands is nearly 16 acres in extent, nearly rectangular in shape, and measures about 1,200 feet from east to west, by 560 feet from north to south. The whole of this ground is covered with buildings of a permanent character, and to secure as much additional space as possible, two long strips of ground between the east and west arcades and the adjacent roads are roofed in by means of temporary sheds; these form the "annexes," which contain the machinery in motion, and the ponderous articles exhibited. The total area roofed in is 980,000 square feet; it is therefore larger than that of the exhibition of 1851 by 189,000 square feet. Lofty walls of brickwork enclose the ground on all sides, and form the walls of the Fine Arts Galleries. The

east and west sides, by being continued past the southern arcade of the Royal Horticultural Society's Gardens, show a frontage of 750 feet, and the frontage on the south side is 1,150 feet. The north front is formed by the lower arcade of the gardens, to which is added an upper storey. The interior space thus enclosed is entirely roofed in by roofs of various heights, and is divided into nave, transepts, aisles, and open courts. These open courts are roofed with glass similar to the Great Exhibition of 1851, but the roofs of all the remaining parts are opaque, and lighted with clerestory windows. There is thus, so far as materials are concerned, a very marked difference between the Exhibition of this year (1862) and that of 1851. The interior supports are hollow cast-iron columns, 12 inches diameter, the metal being half-inch thick. These columns are so arranged as to come at intervals of 25 or 50 feet from centre to centre. All the leading dimensions, vertical and horizontal, are multiples of 25 feet; the exceptions to this rule are the transepts and nave, which are 85 feet wide. The nave runs east and west, and terminates in the centre of the fronts, having its central line 81 feet north of the central line of the building. The transepts extend north and south from the ends of the naves throughout the whole width of the building. The *great domes* are placed at the intersection of the nave and the transepts. The aisles are continued all round the nave and transepts, and the space enclosed by them forms the open or glass courts.

98. The nave is 800 feet long, 85 feet wide, and 100 feet high to the ridge of the roof. The supports of the nave on either side consist of square and round cast-iron columns coupled together. The square columns carry the gallery floor, and the round column, advancing into the nave, receives the principals of the roof. The columns are 50 feet high, in two lengths of 25 feet each. From their capitals spring the roof frames (see fig. 61), which consist of three thicknesses of plank, from 18 inches to 2 feet 6 inches deep, firmly nailed and bolted together, so that their ends break joint. The centre plank is 4 inches thick, and each of the outer ones is 3 inches. The lower edges of these planks are tangential to an imaginary semicircle, round which they form half of a nearly regular polygon. The principal rafters of the roof-frame rise from the top of these posts, and are carried up, after passing a tangent, to the extrados of the arch, to meet at the ridge in a point 25 feet from the clerestory. The angles over the haunches and crown of the arch are firmly braced together to reduce the thrust. In the length of the nave—800 feet—the rib is repeated 30 times. The roof is covered with felt on 1½-inch plank, laid diagonally, so as to brace the whole together. The light is obtained by clerestory windows, one of which is placed between every roof principal; the height of each clerestory is 25 feet, and the design is of three arches, springing from intermediate mullions. The rain water from the roof is carried by means of gutters down the columns supporting the ribs to drains laid under the ground floor. At right angles to the nave, and at each end of it, run the transepts north and south, the length of each of which is 650 feet. The height, width of these, and the construction of the ribs, is the same as in the nave.

Fig. 61.



Section of one-half of a Nave Rib of the Great Exhibition Building of 1862, showing also the Cross Bracing in the Gallery.

99. Twenty-five feet above the ground level are the galleries, following the same line as the aisles. These aisles—50 feet wide—are carried along both sides of the nave and the inner sides of the transept. The galleries following the line of these aisles give an exhibiting space of 203,000 square feet. The floors are carried on cast-iron girders fixed to the columns; over them are laid two strong suspended trusses, carrying the joists and the boarding. With a load on the square foot of surface of 140 lbs—a much greater weight than will ever be laid on—the greatest load one girder can be loaded with is 34 tons, and the breaking weight of each is 88 tons. The roof to the gallery is flat, with felt covering. These galleries form an important feature in the construction of the building. They form an abutment to the nave and transept roofs. The form of bracing by which this is effected was suggested by Mr. Ordish. "The roof thrusting outwards tends to throw the columns out of the perpendicular (see fig. 61); strong iron braces are therefore anchored to the foundation of the inner column and carried up to the opposite outer

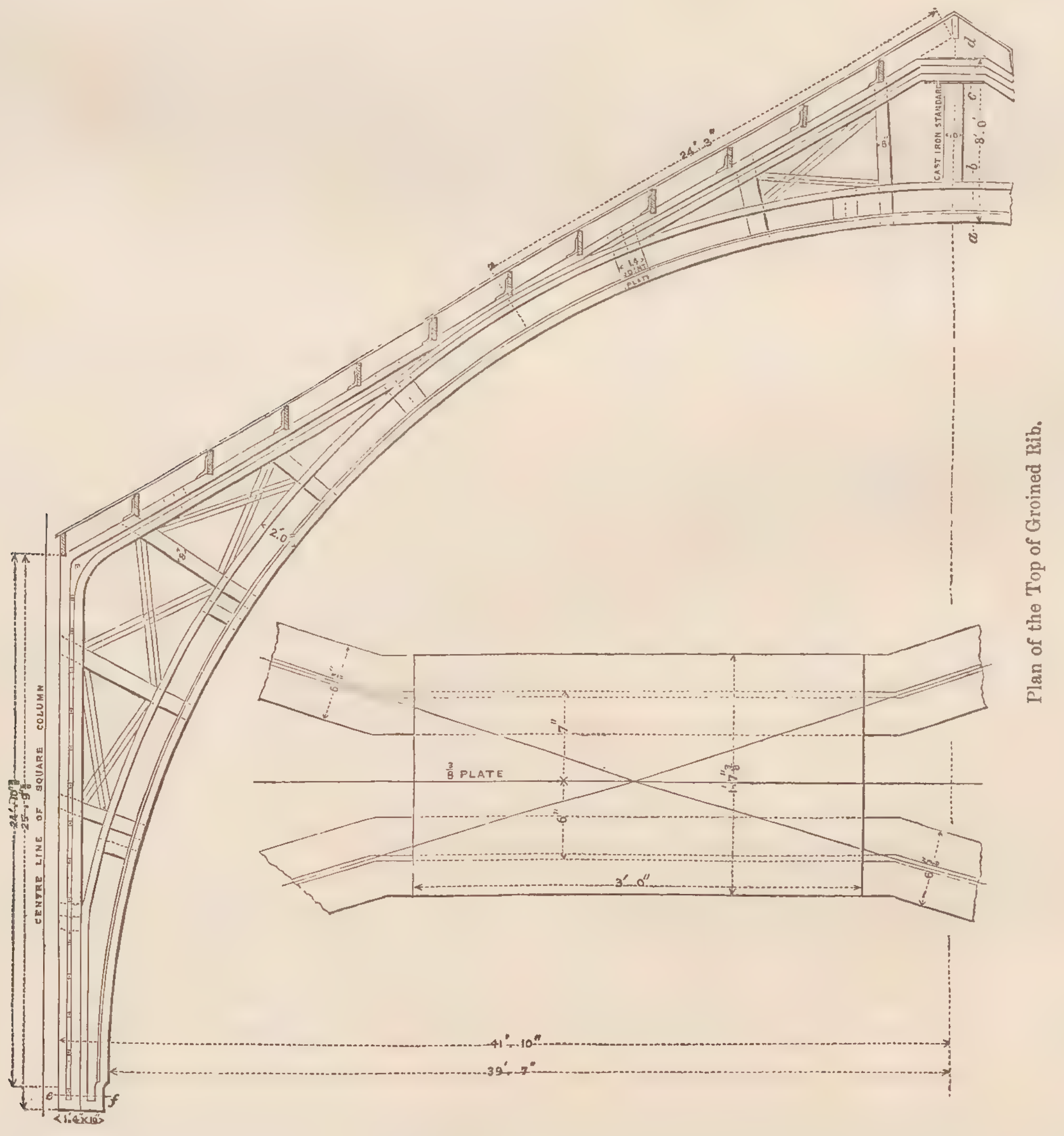
column, which are thus made to counteract the thrust of the roof. Another bracing, anchored to the footing of the outer column, is carried up to the inner column to secure it being acted upon by the force of the wind. This vertical cross bearing is repeated at every 100 feet, or every fourth bay, and by introducing horizontal diagonal bracing under the roof flats, they are turned, as it were, into a deep horizontal girder, supported at two ends by the columns vertically braced as just described. This horizontal girder, therefore, takes the thrust of the three intervening ribs. The way in which the bracing is introduced is very clever, and is an admirable example of the perfect control which the simplest mechanical means, properly applied, gives us in dealing with enormous masses. The bracing is all adjusted by means of connecting screw-links, on a plan very similar to the method of joining railway carriages; by this means it can be tightened at pleasure, and the position of the columns corrected to the minutest fraction of an inch." The principle of the horizontal diagonal bracing, or girder, is exemplified in Tarte and Toovey's plan, illustrated in par. 84 of this Essay, fig. 54. A form of coupling connecting-link is illustrated in par. 57, fig. 44.

100. In the construction and arrangement of parts of the domes and groined ribs of these, very ingenious construction is exemplified. These domes are situated at the intersection of the nave and the two transepts. The intersections of the columns of these, form, at the point where the domes are placed, two octagons. These octagons, although not mathematically regular, are so far regular that their opposite sides are parallel and equal. The length of the sides are alternately 85 feet and 35 feet 5 inches. At the corners or angles of these octagons, columns, 2 feet in diameter, are placed so as to add to the architectural effect, and to carry the groined ribs of the dome. These large columns are raised in three lengths of 95 feet, and are perfectly smooth outside. To obtain this appearance of smoothness, and yet to secure a good joint, the flanges are placed inside, a man having been let down inside to make good the joints by screwing them up. Each column is surrounded by a cast-iron stanchion, 12 feet, the summit of which is exactly 107 feet above the floor of the nave. A gallery, 3 feet wide, is supported on brackets connected with these stanchions. To the upper side of the gallery, and through it to the stanchions, a double wrought-iron tie-plate, acting as the hoop of the dome, is securely bolted. This hoop has the outer plate 10″ × $\frac{3}{8}$″, 10″ × $\frac{3}{8}$″, connected with the inner plate 6″ × $\frac{3}{8}$″, 6″ × $\frac{3}{8}$″, so that both these plates take the thrust of the dome. The dome ribs are bedded on the top of the plates, and the feet of the dome ribs are bolted through to the heads of the stanchions.

101. To return, however, to the groined ribs which support the dome, it has to be stated, that although the chief points of support of the dome are the eight pillars at the angles of the octagons formed by the intersections of the nave and transepts, the plan of the dome itself is a dodecagon. By this ingenious arrangement a twelve-sided dome is seen to stand on an octagon, and by the mode in which additional columns are avoided, and these only required which actually come in and terminate the sides of the nave and transept, an uninterrupted view is obtained through both, and the architectural effect is greatly increased. How this is effected is now to be explained.

102. The last bay of the nave and transept, instead of having a roof resting on wooden principals going straight across, has two iron diagonal ribs crossing it. These form a species of groined arch, the apex of which is a point at the centre of the bay, and on a line with the ridge of the roof. The apices of these groins, and the points in the octagon being joined, a nearly regular dodecagon is obtained, the opposite sides of which are parallel and equal. Eight sides of these, in pairs, are equal to 43 feet 9 inches in length; the four remaining sides come in singly between these pairs, and are 35 feet 5 inches long. The base of the dome is thus formed, having eight sides over the nave and transepts, and four sides over the corners of the aisles, and having a diameter of 160 feet.

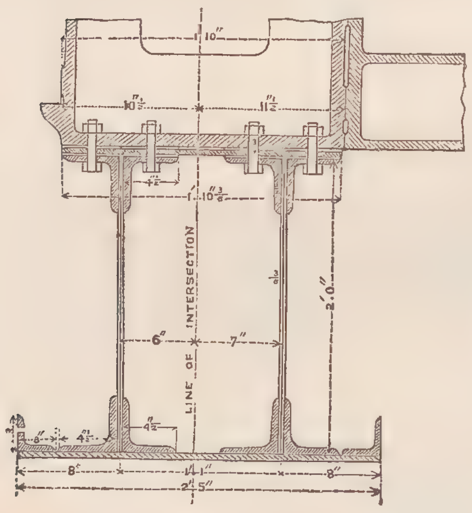
Fig. 62.



Elevation of Diagonal Ribs supporting the Rib of Dome over Nave and Transepts. (Great Exhibition Building of 1862.)

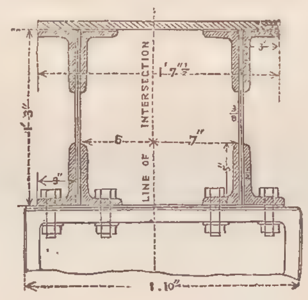
Each groined rib transmits the weight on it to two columns outside the octagon. The dome may thus be said to rest on 16 points, the pressure on the pillars at the angles of the octagon being nearly five times as much as it is on the adjacent columns of the nave and transepts. In fig. 62 we give an elevation of one of the diagonal ribs. The curve forms a semicircle to correspond with the curve of the other ribs; the actual elevation, however, shows a semi-ellipse, the diameter of which—88½ feet—is the diagonal of the rectangle formed by the four supports of the groins. The depth of the rib is 2 feet, with a web of ⅜ inch plate iron; the area of the bottom flange—of angle iron—is 19^{11} inches, and that of the top flange 10$\frac{11}{16}$ inches. The principal rafter is also of iron, the depth of web being 12 inches; the flanges at top and bottom are equal, the sectional area being 20$\frac{5}{16}$ inches. Radial pieces are introduced at distances of 5 feet, connecting the upright and principal rafter with the circular portion of the rib; these pieces are of iron 8 feet by $\frac{5}{16}$ths inch. The ribs at the intersections are strengthened by additional plates, forming at these points, and for a short distance, a box girder. The intersection of the principal rafters and semi-ellipses are connected together with a cast-iron standard, this being continued above the ridge of roof to a point which is 107 feet above the level of the nave floor. At this level the dome ribs, referred to at the end of par. 100, rest. In figs. 63, 64, 65, 66, and 67, are detail drawings, showing the construction of the diagonal ribs.

Fig. 63.



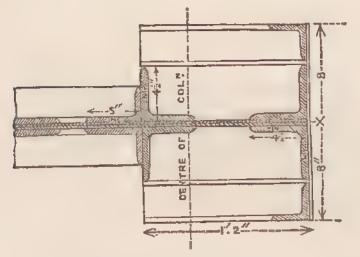
Section on line *a b*, fig. 62, showing junction of Diagonal Ribs at Crown of Arch.

Fig. 64.



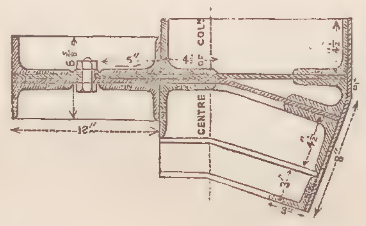
Section on line *c d*, fig. 62, showing junction of top of Diagonal Ribs.

Fig. 65.



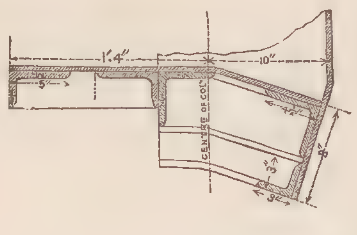
Section on line *e f* in elevation, fig. 62, showing section of seat of Diagonal Rib on corner column of Dome.

Fig. 66.



Section showing seat of Square and Diagonal Ribs in cap of column of Nave.

Fig. 67.



Section of seat of Diagonal Rib separated from Square Ribs.

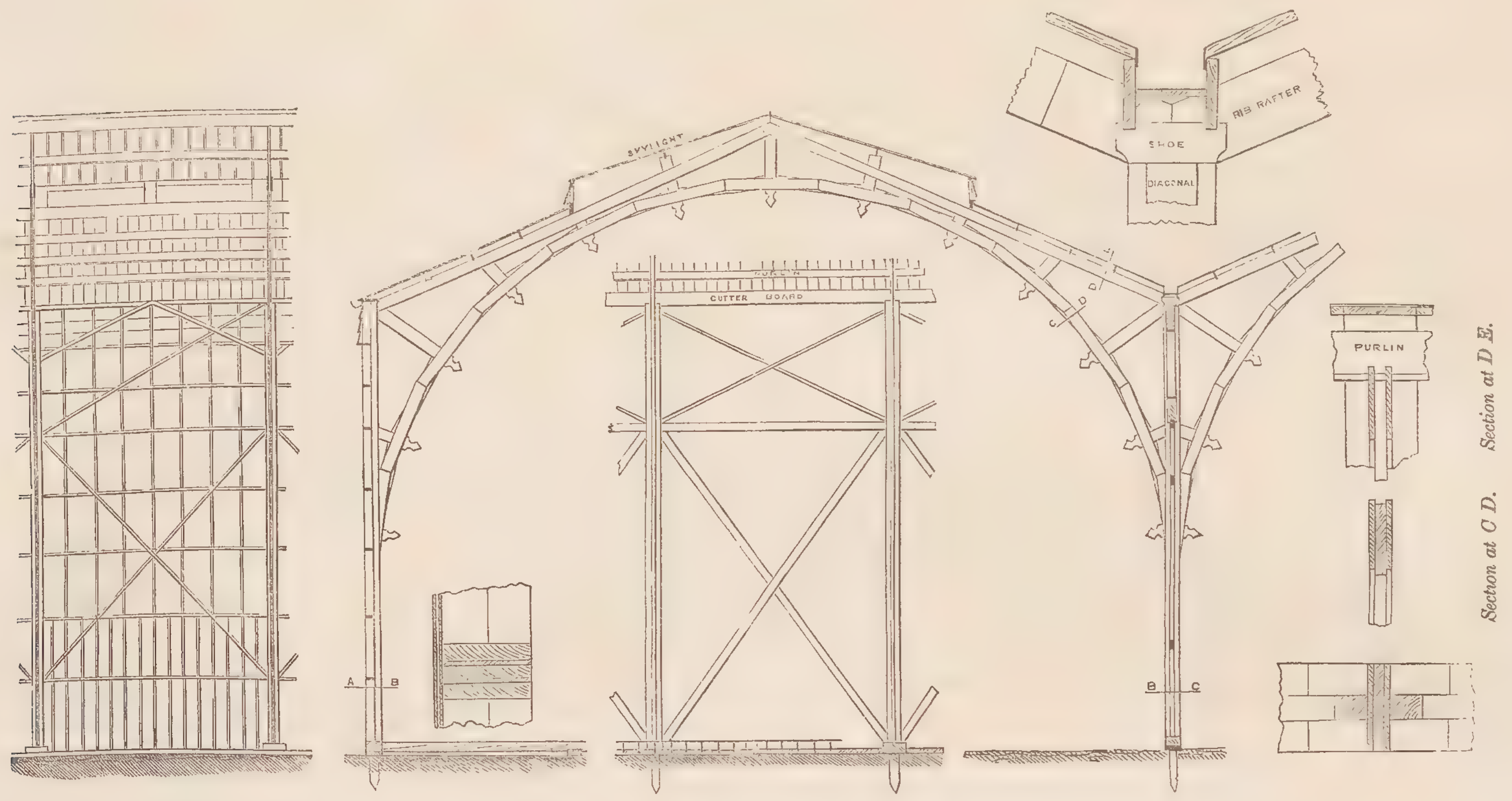
103. We now come to the construction of the dome ribs, which are bedded in the top of the plates forming the hoop of the dome (see par. 100). The dome rib girders are made of boiler plate and angle iron. The sectional area of the bottom flange is 20¾ inches, that of the top 19⅝ inches. There is this peculiarity in the girder, that there is no continuous web or rib between the flanges, but they are joined, at 8 feet intervals, by two pieces of boiler plate, having a 3-inch wood spacing between. The first 7 feet of each rib is vertical, and the girder is here 3½ feet deep. At the top of this portion is the springing line. The top flange then follows a curve of 91 feet 9⅞ inches, the centre of which is a point 12 feet 3$\frac{3}{16}$ inches beyond the centre of the dome. The bottom flange is on a curve, the radius of which is 90 feet 1¼ inch, the centre being 14 feet ½ an inch beyond the centre of dome. The two flanges thus approaching each other as they approach the apex are only 2 feet deep. At this point they are 91 feet from the springing line, and as this is 114 feet above the level of floor of the nave, the total height is 205 feet from this latter point. The twelve ribs all meet at the point 91 feet above the springing line, and abut against a strong cast-iron tube, 1 foot in diameter, and to which they are bolted. To the ribs between the springing and the apex eight wrought-iron purlins are bolted; the divisions between these are strongly braced, making the whole rigid. These purlins are formed of T iron pieces, joined at 6 feet intervals by ½-inch plate. They are not uniform in sectional area, but decrease as they approach the summit. The purlins in the larger triangles of the rib are slightly heavier than those of the other, as they have a longer bearing. The first purlin of a large triangle is 1 foot 8$\frac{9}{16}$ inches deep, the flanges of T iron being 3½″ × 3½″ × ½″. The depth of the web or rib of the upper purlin is 10$\frac{15}{16}$ inches, the top and bottom flanges being of four pieces of of L iron 2″ × 2″ × ¼″. In the small triangles the depth of the lower purlin is 1 foot 8$\frac{15}{16}$ inches, the T iron flanges being 3″ × 2″ × ½″; the upper purlin is 11 inches, the L iron flanges being 2″ × 2″ × ¼″. The crown of the dome for 32 feet down is covered with ornamental zinc; the remainder is glazed. To carry the glass, sash-bars of iron are rivetted to the purlins at distances of every 18 inches; every fifth bar is stronger than the others. This is done to assist the cross bracing, and to prevent the purlins twisting.

104. We now describe the constructive features of the annexes, or temporary buildings attached to the Exhibition building. These are designed to contain the heavy goods and the machinery in motion. The western annexe is 975 feet long; it is not of uniform breadth throughout, 720 feet of it being 200 feet wide, the remainder 150 feet. "It is covered," says Captain Phillpott, "by a ridge and valley roof, supported on most ingeniously constructed light wooden ribs of 50 feet span, placed at 15 feet intervals. These ribs are similar in construction to those of the nave, that is, they are formed of planks nailed together, but they are very much lighter. The circular portion springs at a height of 10 feet above the ground line. Its elevation is nearly half of a regular polygon, described about a semicircle, whose diameter is 50 feet; it consists of three planks, 9 inches wide; the centre plank is 1¼ inch thick, and has nailed to it on either side a ¾-inch plank; the ends, breaking joint all through the principal rafters, which are composed of two ¾-inch planks, rise from a point 28 feet above the ground, and meet above the curved ribs, so as to make the ridge 5 feet above the crown of the arch. The upright, which has its foot morticed into a sleeper resting on piles, is formed of 1¼ inch centre plank, with a ¾-inch plank on each side, having a strengthening piece 4 inches by 3 inches spiked to it on either side to prevent its bending. The principal rafter and upright are connected with the curved rib by radial pieces of 1¼-inch plank, which are brought rather below the intrados of the curve, and finished off for the sake of ornament by a spear head. The roof-frames are therefore merely planks nailed together, and so disposed that the weight comes on their edge. One-half of the roof is covered with boards and felt, and the other half has a glazed skylight, with louvres for ventilation throughout the whole

length. The span of each rib is 50 feet, so that in the 200 feet width there are four spans, and in the 150 feet three."

We give in fig. 68 various drawings illustrative of the constructive features of the annexe, which are so simple that it requires no framing, and any one accustomed to drive a nail and saw a plank can fit up the ribs. Each of the ribs was made in a horizontal position over a full-sized drawing on the floor, and was hoisted to its position by means of a derrick, the rib swinging vertically, and stiffened while being raised by scaffold-poles tied across the angles. The frames are braced together at the top of the uprights, and to prevent buckling the ribs are strutted to the wall plate.

Fig. 68.



Detail of Valley Gutter.

Inside elevation of Walls between Ribs.

Section at A B. TRANSVERSE.

Elevation between span of Ribs showing Divisional Bays.

SECTION.

Section at B C.

105. As a practically useful conclusion to our paper, we give a series of notes on various points connected with iron construction. These are the deductions made from the evidence given by all the eminent Engineers of Great Britain before the Commission appointed to inquire into "the uses of iron for railway structures." The report of this Commission abounds in valuable facts connected with iron as used for constructive purposes, but as it is almost entirely inaccessible to the majority of readers, we believe we are doing ours a service by reproducing here the most important part of the epitome of evidence which concludes the Report:—

106. "*Proportion of Load to Breaking Weight in Girders.*—There appears to be a considerable difference of opinion as to the proportion between the greatest load which a girder should be allowed to bear and the breaking weight. There are two conditions under which the weight may be applied, viz.:—1st. When stationary, as in the case of water-tanks, floors, &c.; 2nd. When the weight moves so as to cause concussions and vibrations, as in railway bridges. In girders required for the first case, Mr. Fox and Mr. T. Cubitt consider that the breaking weight should be three times the greatest load, Mr. P. W. Barlow four times, and Mr. Glynn would not make it less than five times the load. In girders for railway bridges Mr. Brunel states that he allows the load to be $\frac{1}{3}$d or $\frac{2}{5}$ths of the breaking weight; but he considers that the rule he adopts for calculating the dimensions of his girders gives more than the usual strength; Mr. Grissell and Mr. Charles May consider $\frac{1}{3}$d to be sufficient; Mr. Rostrick, Mr. P. W. Barlow, Mr. R. Stephenson, and Mr. Joseph Cubitt, adopt $\frac{1}{6}$th; Mr. Hawkshaw prefers $\frac{1}{7}$th, except in cases where great care is exercised in the selection of materials and workmanship, when a smaller proportion would suffice; and Mr. Glynn considers that in structures exposed to concussion and vibration the ultimate strength of a girder should be 10 times the greatest load."

107. "*Test of Girder.*—The general opinion as to the amount of test which should be applied to girders is that the test should amount to twice the greatest load. Mr. Joseph Cubitt would employ three times the greatest load, or half the breaking weight; and Mr. Thomas Cubitt considers it safer to test a girder almost to the extent that would break it than not to prove it at all, as the testing of girders is the only means of discovering defects under the surface and concealed from the eye. Mr. Brunel, however, thinks that a girder should not be tested with a weight exceeding the greatest load, as the object in testing is to ascertain the soundness of the casting, which may be judged of by its appearance under the load, and all risk of permanent injury should be carefully avoided. Mr. Rostrick, Mr. Glynn, and Mr. Joseph Cubitt, recommend that blows be applied to cast-iron girders when under the testing load; Mr. Hawkshaw and Mr. P. W. Barlow consider that where actual weight is used, sufficient vibration is given to the beam by throwing the weight into the scales used in testing. It is stated that for convenience sake girders are usually tested by means of the hydraulic press; but Mr. Fairbairn, Mr. Locke, Mr. Brunel, Mr. Joseph Cubitt, and Mr. Fox, prefer using actual weight, on account of the uncertainty as to the actual pressure the hydraulic press brings upon the girder, though the latter gentleman considers that all liability to error in the press is obviated by an improved construction which he has adopted. Mr. C. May states that, as girders are bought at the lowest possible price per ton, the manufacturer is compelled to adopt the most convenient, and not the best mode for testing them, or ten times his profit would not pay him for the experiment."

108. "*Length for Simple Cast-iron Girders.*—The use of simple cast-iron girders in bridges appears to be limited only by the power to make sound castings (which arises chiefly from the difficulty of pouring the metal equally), and the inconvenience of handling large masses. Mr. Rostrick, however, would not put any limit to the length. Mr. Hawkshaw considers that they may safely be made more than 50 feet long; in which opinion Mr. Fox and Mr. Grissell concur, but name 60 feet as the limit. Mr. Glynn, Mr. Charles May, and Mr. Joseph Cubitt, would make them 40 to 50 feet. Mr. P. W. Barlow, Mr. Fairbairn, Mr. W. H. Barlow, and Mr. Stephenson, state 40 feet as the limit; and Mr. Brunel states 35 feet, as he does not consider that sound castings can be ensured to a greater length. Mr. Fairbairn, however, mentions a girder in Holland, 70 feet long, cast in one piece."

109. "*Form for Simple Girders.*—It appears to be universally admitted that the form resulting from Mr. Hodgkinson's experiments on the tension and compression of iron is that which gives the greatest strength, but the actual proportions are generally modified to suit the varying circumstances under which girders are employed. Mr. Stephenson sometimes makes the top flange equal to the bottom one, but usually in the proportion of 3 to 5, partly to obviate any risk from unequal cooling of the materials, and partly from the necessity of having a large top flange to bolt the flooring to. In preference to using a single girder, Mr. Stephenson recommends two girders to be bolted together, with a balk of timber between, to which the rail is fixed. Mr. Hawkshaw, Mr.

Fox, and Mr. Joseph Cubitt, recommend that the top flange be increased to beyond the proportions given by Mr. Hodgkinson, in order to resist the lateral tension. Mr. W. H. Barlow and Mr. Locke would use the arched form of girder whenever practicable; and the former gentleman says the straight girders have been in fashion, and consequently more used than practice actually required. Mr. Fox, in girders subject to dead weight only, would make the proportion of the top flange to the bottom one as 1 to 6; but in railway bridges he recommends 1 to 4. Mr. Thomas Cubitt mentions that shoes or sockets, or any projections cast on girders, have a tendency to create flaws from causing the dirt to accumulate in those places, and he considers that the shape which will ensure a sound casting should be as much considered as the theoretical form of greatest strength."

110. "*Deflection of Girders, and Effects of Permanent Loads and Change of Temperature.*—It is considered that girders should not deflect more than from $\frac{1}{600}$th to $\frac{1}{400}$th of their length, according to the form of the girder. It does not appear from the evidence that a weight, equal to what a girder is constructed to carry, will, even if left on for any length of time, cause the deflection of the girder to increase, unless subjected at the same time to considerable changes of temperature. Some experiments, made by Mr. Fairbairn and Mr. Broadwood, show that iron loses a considerable proportion of its strength when heated to a temperature of more than 220° Fahrenheit, and that it becomes uncertain below 32°. Mr. Clarke described the effect of the sun coming out and shining on the Conway tubular bridge for half-an-hour to have been to raise the tube vertically one inch; and he mentions that at night, from the lower temperature, the deflection was always greater than in the daytime. Mr. Fox instances the effect of frequent and great changes of temperature on some short girders, 6 feet long, which support the hoods of the forges in his workshops. In the daytime they are so warm that the hand can only just bear the heat; at night they become cold. The effect is to make the girders *swag*, and the swagging appears to be continually increasing. Some have attained as much as 3 inches deflection in the centre, but their strength does not seem to be impaired. The general impression of engineers appears to be that the deflection caused by passing a weight at a high velocity over a girder is less than the deflection which would be produced by the same weight at rest; and the increase observed in many instances is attributed by Mr. Locke, Mr. Stephenson, and Mr. Fox, to the inequalities at the junction of the rails, or to the jerks of the engine.

111. "*Box, or Tubular Girders.*—Mr. Fairbairn considers these girders the best for large spans, and, from some experiments he made, considers them capable of resisting, not only dead weight, but also impact. Mr. Stephenson states that they are cheaper and more elastic than other forms for spans of more than 40 feet; and he recommends that the top should be made of cast-iron to resist compression. Mr. Glynn and Mr. Locke mention that they have been used for steam-engines for some time, and considers the plan sound. Mr. Brunel looks upon the introduction of wrought-iron into the construction of girders as the most important step that has been taken for some time in engineering; and he considers that, with ordinary care, and with the improvements which have been introduced in the mode of riveting, the joints made by riveting may be as permanent, and in every respect equal to the other parts of the structure, and he does not consider oxidation or vibration can effect them. With respect to riveting, Mr. Brunel considers that two plates could be riveted together so as to ensure their not breaking in any part contiguous to the rivets or joints, because the rivets should not act as pins or bolts, but as clamps, which, by pressing the plates together, produce an enormous friction. Mr. Clarke, however, who has made a good many experiments on the subject, does not appear to have obtained so close an union of the plate, as he states that they generally broke at the riveting. Mr. Hawkshaw has adopted wrought-iron girders for large spans; the box form is adopted to produce lateral stiffness. Mr. Fox and Mr. Rostrick consider that a large structure, like the Menai Bridge, must be subject to sudden compression and extension from the changes of temperature. Mr. Stephenson does not consider suspension bridges applicable to railways, except to a very small extent; and he states that he has been informed that an engine and train passing over one at Stockton (which has since been replaced by a girder bridge), pushed the bridge like a wave in front of it. Mr. Brunel states, under very peculiar circumstances he once proposed a suspension-bridge himself. Mr. Brunel considers that the lattice bridge is advantageous only under circumstances which would prevent materials of more than a certain length being procured. Mr. Stephenson objects that the compression cannot be carried through them, and that the base through which the strain has to be carried is not sufficiently broad. It is stated, however, that Sir J. McNeil has remedied the want of power to resist compression by introducing a cast-iron top."

112. "*Change of Internal Structure in Iron.*—Mr. Rostrick mentions that at the Pontypool Iron Works a bar of wrought-iron, suspended, and continually struck by a hammer at the bottom, dropped in two after a length of time; but he knows of no instance of a change of structure on railways. Mr. Hawkshaw, though he has observed crystallization in broken rails and axles, has not traced it directly to vibration; he thinks mill-gearing and shafts would furnish good examples, though when they break, the various circumstances under which the fractures have taken place should be observed. Mr. Grissell has observed that the vibration to which crane chains are exposed changes the iron from very beautiful malleable iron to the crystalline appearance of cast-iron. He does not consider that cast-iron is subject to the alteration of structure. Mr. Fox considers that vibration does produce a change in the internal structure of wrought-iron, and instances that if the thread of a screw be cut in a wrought-iron bar, and that the bar be broken across the tapped part, the fracture there will be found more crystalline than at the other part; he mentions the frequency with which shafts and mill-gearing break, and states that cold-hammering the axles to give them a high polish changes their internal structure, but instead of remedying the evil by annealing, he recommends that they should be finished at a high temperature. Mr. Grissell mentions that chains of cranes often break with a crystalline fracture, which he attributes to a change in the internal structure, but he does not consider the same effect is produced in cast-iron. Mr. Fairbairn states, that repeatedly making a wrought-iron bar red hot, and plunging it into cold water, renders it crystalline, and that the fibrous texture may be restored by annealing; he considers that percussion renders the fibres more liable to break off short, but that without it is sufficient to cause a considerable increase of temperature it does not produce any real internal change. Mr. Glynn considers that the structure both of wrought and cast-iron is altered by a succession of blows, the wrought to a crystalline structure, the cast to larger crystals; he has observed this appearance particularly in axles, mill-shafts, toothed wheels, crow-bars, and crane chains, the latter, even when specially of strong fibrous iron, require to be annealed after about three years; the axles of tenders, to which breaks have been applied, he mentions as particularly subject to this change. He attributes the alteration to galvanic action, induced by the alloys from which iron is never entirely free, and considers that the action is increased by blows. He also mentions that brass wire, of copper and zinc, originally tough and fibrous, continually breaks off short with a crystalline fracture radiating in the form of a star, showing a change in the structure such as would have taken place if the metal had been melted and had crystallized in cooling; this effect is more rapidly produced in an atmosphere containing sulphuric acid. Mr. W. H. Barlow mentions having caused a piece of fibrous iron to be hammered for a long time by a blacksmith, and that he found the iron changed from a fibrous to a crystalline structure; but as axles do not undergo the same sort of hammering, he does not know whether the same effect takes place in them. Mr. Stephenson considers the fact of an alteration of structure as highly improbable, and cites the connecting-rod of an engine having vibrated 25,000,000 times, and yet being perfectly fibrous. In the cases of axles the iron may not have been fibrous in the first instance, for though when a piece of iron is rolled from 1 foot in length to 20 feet, it necessarily becomes fibrous; it does not necessarily become so when rolled from 1 foot in length to 6 feet. He says that in all the cases of change of structure which he has heard of there has always been some important link wanting. Mr. Locke considers that concussion would alter the structure of iron, but would not offer an opinion as to whether the fracture of axles arose from that cause; he mentions that a great many axles broke when the crank axles were in use, but that since straight axles have been adopted fewer breakages have occurred. Mr. Brunel doubts the change of internal structure, and thinks the various appearances of different fractures result as much from the mode in which the iron has been broken as in any change in structure, and that change in temperature will also produce a variation in the fracture. . . . Mr. Brunel exhibited various specimens broken, some with a fibrous fracture by means of a heavy slow blow, and some with a crystalline fracture by means of a short sharp blow. Mr. Charles May cites the beam of a steam-engine as an instance of continued vibration not affecting iron, and mentions as an instance in favour of the change, the fact that a gun used in his works to break pig-iron across, at last dropped in two as if it had been cut."

BUILDING MATERIALS:

STONE, ARTIFICIAL STONES, CEMENTS, BRICKS, TIMBER;

STRENGTH, DECAY, AND PRESERVATION OF.

1. Stones.—Stones may be divided into three classes—*Granites*, *Sandstones*, and *Limestones*. Mr. Burnell's classification is perhaps the most practical; in this there are only two divisions, these being made according to the mechanical properties of the stones—(1.) those which can be worked by the pick or by the "wedge;" and (2.) those which can be worked by mallet and chisel. The first of these are stones which do not, the second those which do work freely. "These classes in their turn," says Mr. Burnell, "are susceptible of numerous subdivisions, such as, *in the first class*, the granites, porphyries, basalts, whinstones, and the countless varieties of the plutonic and volcanic formations, the quartz rocks, mica schists, gneiss, and the more dense altered quartzose sandstones, the quartzose conglomerate, and the grès, or agglutinated sandstones of the secondary and tertiary strata. The slate rocks, perhaps, might be grouped as a sub-class of the stones not workable by the mallet and chisel, for they present too decidedly-marked a cleavage to allow of their being worked freely, though they are susceptible of being sawn, or even worked on the edge, in the same manner as the freestones themselves. In the *second class*, or freestones, are comprised the marbles, sandstones, limestones—both carbonates and sulphates—in all their endless modifications. The bituminous rocks furnish materials which may be classed as a sub-variety of the freestones, in an analogous manner to the classification of the slate rocks in the preceding division."

2. The following may be taken as a pretty full list of the building-stones in general use:—*Granites:* Aberdeen (bluish-grey, 185 lbs.);[*] Peterhead (red, 185 lbs.); Devonshire (grey, 185 lbs.); Cornish (grey, 185 lbs.). *Sandstones:* Craigleith (grey, 145 lbs.); ordinary York (yellow, 160 lbs.); Derbyshire, Darley Dale (light brown, 148 lbs.; Yorkshire, Hare Hall (light brown, 141 lbs.); Yorkshire, Bramley-fall (brown generally, 14 cubic feet to the ton). *Limestones:* Portland (whitey-brown, 146 lbs.); Bolsover (light brown, 151 lbs.); Anston Moor (light brown, 150 lbs.); Aubigny (pale yellow, 16 cubic feet to the ton); Caen (cream-coloured, 17 cubic feet to the ton); Mansfield, Nottingham (white, red, yellow, all about 17 cubic feet to the ton). *Bath Stones:* Boxhill (cream-coloured, 123 lbs.); Farleigh Down (cream, 116 lbs.); Dundry-hill (lightish brown, 17 cubic feet to the ton); Coombe Down (cream, 116 lbs.). *Marbles:* Carrara (white, 160 lbs.); Sicilian (white ground with greyish tints); Sienna (violet veins in a rich yellow ground, 180 lbs.); Devonshire (black, ditto veined with red, grey, or white lines, 13 cubic feet to the ton); Purbeck (grey and red, 14 cubic feet to the ton); Welsh (green, 14 cubic feet to the ton); Irish (grey-black and green, 14 cubic feet to the ton); Serpentine, from Cornwall (red-green, veined with brilliant lustre, 13 cubic feet to the ton); Derbyshire (black-grey, purple-tinged, 14 cubic feet to the ton). The strength of stones is a subject to which comparatively little attention has been paid, and yet it is one of considerable importance. The strain to which stone is usually subjected is a crushing one; it is rarely subjected to a tensile strain excepting in the case of very pronounced and overhanging mouldings, or in the case of projecting corbels which support weights, as stairs, &c., &c. In Weale's "Engineers' and Contractors' Pocket Book"—a most useful book of reference—a table is given, showing the weight in lbs. required to crush $1\frac{1}{2}$-inch cube of stone. This we reproduce:

Chalk,	1,127 lbs.
Red Brick,	1,817
Derby Grit,	7,070
Portland Stone,	10,284
Craigleith Stone,	12,346
Yorkshire Paving Stone,	12,856
White Statuary Marble,	13,632
Bromley Fell Sandstone,	13,630
Cornish Granite,	14,302
Dundee Sandstone,	14,918
Compech Limestone,	17,354
Purbeck Stone,	20,610
Black Brabant Marble,	20,742
Very hard Freestone,	21,254

The strength of the artificial stone patented by Mr. Ransome, and described in a future paragraph, is, as compared with Portland stone, as 2,122 to 750, and with Caen, 780. Thus, a bar of the artificial stone, 4 inches square in section and 8 inches long between supports, carried in the centre of its length, 2,122, while similar bars of Portland and Caen carried only 750 and 780. Again, a cube 4 inches sustains 30 tons, while the adhesive force of the artificial stone, being represented by 1,980, that of Portland stone is 1,104; Caen, 768; Bath, 796; Elland Edge, 1,874. The following gives the weight of a cubic foot in lbs., and the number of cubic feet in a ton of the stones named—Marble, 170, weight of cubic foot in lbs., 13 cubic feet to the ton; granite, 165, $13\frac{1}{2}$; Portland stone, 160, $13\frac{3}{4}$; Craigleith stone, 147, 15; chalk; 173, $12\frac{3}{4}$; brick, 125, 17.

3. Causes and Prevention of Decay in Stone.—The causes of decay in stones used in buildings are partly chemical, partly mechanical: of the chemical, the most import-

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[*] The remarks within parentheses give, first, the colour, and second, the weight per cubic foot of the stone, of which the name precedes.

ant are the "chemical reactions which take place in the ingredients of the stones themselves, and the new forms of matter which are supcrinduced from without, of a nature to affect the stability of the original combination." The mechanical causes are "the dissolving properties of atmospheric moisture, in its various forms of rain or mist," and "the disintegrating action of changes in atmospheric temperatures."

4. The following, on the causes of decay in stones, is from the Report of the Royal Commission appointed to investigate the nature and properties of the stones employed, or proposed to be employed, for the construction of the Houses of Parliament at Westminster:—

> "As regards the sandstones that are usually employed for building purposes, and which are generally composed of either quartz or silicious grains, cemented by silicious, argillaceous, calcareous, or other matter, their decomposition is effected according to the nature of the cementing substance, the grains being comparatively indestructible. With respect to limestones composed of carbonate of lime, or the carbonate of lime and magnesia, either nearly pure or mixed with variable proportions of foreign matter, their decomposition depends, under similar circumstances, upon the mode in which their component parts are aggregated, those which are most crystalline being found to be the most durable, while those which partake least of that character suffer most from exposure to atmospheric influences. The varieties of limestone termed oolites (or roestones), composed of oviform bodies cemented by calcareous matter of varied character, will, of necessity, suffer unequal decomposition, unless such oviform bodies, and the cement, be equally coherent and of the same chemical composition. The limestones which are usually termed *shelly*, from their being formed of broken or perfect fossil shells, cemented by calcareous matter, suffer decomposition in an unequal manner in consequence of the shells, which, being for the most part crystalline, offer the greatest amount of resistance to the decomposing effects of the atmosphere. Sandstones, from the mode of their formation, are very frequently laminated, more especially when micaceous, the plates of mica being generally deposited in planes parallel to their beds. Hence, if such stone be placed in buildings with the planes of lamination in a vertical position, it will decompose in flakes according to the thickness of the laminæ; whereas, if it be placed so that the planes of lamination be horizontal—which is most common in its natural, or *quarry*, bed—the amount of decomposition will be comparatively immaterial. Limestones—such, at least, as are usually employed for building purposes—are not liable to the kinds of lamination observable in sandstone; nevertheless varieties exist, especially those called shelly, which have a coarse laminated structure, generally parallel to the planes of their beds, and therefore the same precaution in placing such stone in buildings, so that the planes of lamination be horizontal, is as necessary as with sandstones, above noticed.
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> "The chemical action of the atmosphere produces a change in the entire matter of the limestones, and in the cementing substance of the sandstones, according to the amount of surface exposed to it. The chemical action due to atmospheric causes occasions either a removal or disruption of the exposed particles—the former by means of powerful winds and driving rains, and the latter by the congelation of water forced into, or absorbed by, the external portions of the stone. These effects are reciprocal, chemical action rendering the stone liable to be more easily affected by mechanical action, which latter, by constantly presenting new surfaces, accelerates the disintegrating effects of the former.
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> "Buildings in this climate are generally found to suffer the greatest amount of decomposition on their southern, south-western, and western fronts, arising, doubtless, from the prevalence of winds and rains from these quarters; hence it is desirable that stones of great durability should at least be employed in fronts with such aspects. Buildings situated in the country appear to possess a great advantage over those in populous and smoky towns, owing to lichens, with which they almost invariably become covered in such situations, and which, when firmly established over their entire surface, seem to exercise a protective influence against the ordinary causes of the decomposition of the stones upon which they grow."

5. The power of the atmosphere (see par. 3) in acting upon or dissolving stones, seems to be greatly dependent upon the quantity of free carbonic acid gas held in solution by it. The rain-water of a large town like London, for instance, holds much of this gas, as also of sulphuric acid and ammonia, which act deleteriously upon the carbonates of lime in stones of this class, as well as upon the silicates of potash and soda in stones of the igneous rocks. Much of this atmospheric or rain action depends upon the mechanical nature of the stones themselves. Stones of a crystalline character are best suited to resist the beating influence of rain; those of an irregular, confused, earthy texture the worst. "But atmospheric moisture," says Mr. Burnell, "when absorbed into building-stones, acts upon them quite as much through the changes in its own volume, in passing from the liquid to the solid state at the time of frost, as it does by the chemical dissolution it produces. If the stone should be placed in such a manner as that water should accumulate in any perceptible quantities between its various layers, and if the position of those layers be such that the expansion of the water in freezing cannot take place freely, the respective layers containing the water will be violently detached from one another. Now, all stones, even the crystalline limestones and slates, have certain planes or directions of cleavage, or of stratification, along which water flows more readily than in any other course. If the stones be placed in a building with those planes in a direction likely to retain rain falling upon, or absorbed through, the surface (which is the case when stones are placed 'bed to weather'), disintegration must ensue unless the edges of the beds be left free, and even in that case there is danger of frost detaching one layer from another. It is, indeed, a primary law of construction that every stone should be laid 'bedwise,' and few modern theories have produced so much practical mischief as the one lately propounded, that 'it was a matter of little importance in what direction of the bed a stone was laid.' Fortunately, even unpractised eyes can detect the bedding of the majority of the London building-stones, either from the position of the fossils or the variety of texture or of colour; in the less distinctly marked stones even practised eyes can detect the planes of cleavage, and a good workman will hardly ever be mistaken in his judgment. It is unfortunate that the modern system of competition throws so great a temptation in the way of the practical builder as to render it a mere matter of chance whether the constructive law above mentioned be observed or not, unless a costly system of supervision be organized, and thus the precautions often taken by the stone merchants to indicate the upper bed of the material he delivers are defeated." The chemical reactions (see par. 3) which cause the decay of stones are chiefly those arising from the oxygenization or hydration of their component parts. If oxide of iron, for instance, is present in quantity, changes are apt to be induced disturbing the normal condition of the stone. The mineral salts, silicates, and sulphates of iron, so often present in stones, are also apt to become decomposed. Of the third cause (see par. 3), by which stones are liable to injury by reason of the "new forms of matter they superinduce," the most noted is the efflorescence, or "saltpetring," which exudes from the surface, and gradually disintegrates it, through the expansive action of the crystals as they form.

6. On reviewing the causes of decay in stone, the practical result is that the chief cause which builders have to combat with is damp, arising either from the direct source of a wet foundation, or from the dampness of the atmosphere, or from the rain. "In combating this evil," says Mr. Burnell, the great authority on Building Materials, and from whose able paper, read before the Society of Arts, we have liberally extracted, "the precautions to be observed are very simple, and they only require a little common sense on the part of the builders charged with their application, to the materials at least which have been long before the public." Mr. Burnell then proceeds to point out what these precautions are, of

which the following is a brief *resumé*:—The most important rule is never to employ absorbent stones in the ground, or in the elevation, unless where the former are kept constantly wet, and the latter where the absorption of moisture from the ground is prevented by the interposition of some impermeable material. Absorbent stones should never be employed for projecting parts of buildings, as cornices, &c., where water may lodge. The mortar used for such stones should not be that likely to cause efflorescence or nitrification. Where, however, absorbent stones are used without sufficient precautions being taken to prevent their decay, this decay will inevitably set in, and display its worst virulence in the zone of alternate dryness and wetness, or, as workmen say, "between wind and water." The best mode, however, of building is to adopt a plan somewhat similar to that of continental builders, who use stones of different quality according to their position in the building, as, for instance, non-absorbent stone in the basement, the absorbent in those parts least exposed to atmospheric action or rain.

7. But even when every such precaution is taken, it is still essential to protect the surfaces of soft and absorbent stones at those parts most exposed. This is usually done by painting the surfaces with ordinary paint, allowing the stone to absorb fatty matter. Both of these plans are very defective, and the consequence is, that where adopted they have frequently to be removed. Attention has therefore been paid of late to the discovering of more scientifically correct modes of preservation. These we now describe briefly.

8. The first of the methods lately introduced which we describe is that of Kuhlmann, which has for its object the "conversion of the material itself into an insoluble non-absorbent substance." The following is M. Kuhlmann's method:—"Two and a quarter parts of silica (flint or clean sand) are fused with one part of potash; it is then dissolved by boiling under pressure in from eight to ten times its weight of water. The stone-work of old buildings is thoroughly cleansed of all that might prejudice its absorbing qualities. Troughs nugged with clay are placed against the part of the building intended to be silicated, so as to collect the solution, which is applied with a syringe at intervals of three or four hours for about four days, or till the stone has ceased to absorb. It is considered desirable that this process should be repeated, but to a less extent, the following year. The colour of the stone is not materially changed, provided the absorption is tolerably equal, and the silicalization effected by a number of applications of weak solutions, both of which conditions are necessary to success." The following is the *rationale* of the process:—"The carbonic acid of the atmosphere separates the silica from the potash, leaving it deposited in the pores of the stone, when, should the carbonate of lime be present—as in limestone—it combines with it, and forms the silicate of lime, while the soluble salt—viz., the potash—is removed by the rain or other means."

9. Beautifully correct in principle as this method is, it is unfortunately so slow in its action that when exposed to rain the solution is often found to be washed out. Another objection is that it causes frequently an unsightly efflorescence on the surface. Attention has therefore been recently directed to Ransome's patent for indurating stone, the object of which is to fill the pores of the stone with an insoluble material which prevents the entrance of water. This material is a silicate of lime, which possesses most enduring properties. This is produced by first washing the surface of the stone with a solution of the silicate of soda (soluble glass), and applying thereafter a solution of chloride of calcium (muriate of lime). A double decomposition takes place, the silica combines with the calcium, forming a solid silicate of lime, which remains in the pores of the stone; and the chlorine combines with the soda, and forms common salt, or chloride of sodium, which effloresces to the surface, and is easily washed off by the rain or special washings. In using this indurating wash the "surface of the stone, &c., should be thoroughly cleaned by the removal of any extraneous matter, and the prepared silicate should then be laid on evenly with a brush. As soon as this is properly absorbed, and before it has had time to dry, the prepared calcium, diluted with an equal quantity of water, should be applied, and well worked upon the silicate with a stiff brush until all froth has disappeared in the pores of the stone. When dry, a second coating of the prepared calcium should be applied to insure the complete neutralization of the silicate. Should the stone be of a very absorbent character it may require a second dressing, in which case it is better to allow the first application to get thoroughly dry, and then proceed in the same manner as before. About four gallons of each solution will be required for every hundred yards of surface." This material is coming rapidly into use, and is applicable to sandstones, limestones, plaster, bricks, or cement. Kuhlmann's material is only applicable to the carbonates of lime.

10. Artificial Stones.—Numerous patents have been taken out for the making of artificial stone, by which elaborately carved or ornamented surfaces or complicated forms could be produced at a very reasonable rate. Perhaps the best of all these materials is that known as Ransome's Artificial Stone. In the last paragraph, while describing Ransome's indurating wash for stones, we noticed that one of the combinations formed was a solid silicate of lime. Mr. Ransome's attention was directed to the "enormous cohesive properties" of this silicate, and he was prompted to discover a mode of applying it to the formation of artificial stone. The following is a statement of the result of his investigations:—Quantities of chalk, common sand, or other suitable mineral materials, with a solution of silicate of soda, so that the combined substances can be moulded into any form, or rolled into slabs as desired. These forms, blocks or slabs, are then washed with a solution of calcium, or dipped into it. The effect is instantaneous; and the soft material is converted into a hard, insoluble substance, capable of resisting the weather, and of getting harder the longer it is exposed. Dr. Edward Frankland, who was appointed to inquire into the causes of the decay of the stones of the Houses of Parliament, in writing of the tests to which this new stone was subjected, says:—"The chief object of these experiments was to expose the samples to influences similar to those to which the stones themselves would be subjected when used for outside work in our large cities; but in order as far as possible to arrive within a moderate time at results which, under ordinary circumstances, would only be obtained after the lapse of many years, it was necessary to intensify those influences by presenting the various chemical reagents to the stone more continuously, and in a more concentrated form, than would be the case in the ordinary atmospheric degradation to which building-stones are exposed.

"The experiments were made in the following manner:—The samples were cut as nearly as possible of the same size and shape, and were well brushed with a hard brush. Each sample was then thoroughly dried at 212°, weighed, partially immersed in water until saturated, and again weighed; the porosity, or absorptive power of the stone, was thus determined. It was then suspended for forty-eight hours in a very large volume of each of the following acid solutions, the alterations in weight after each immersion being separately estimated. Solution No. 1—water containing 1 per cent. sulphuric acid; solution No. 2 containing 2 per cent. sulphuric acid; solution No. 3, water containing 4 per cent. sulphuric acid. The sample was then boiled with water until all acid was removed, and again weighed. Finally, it was dried at 212°, brushed with a hard brush, and to the total degradation or loss since the first brushing was ascertained."

"There was no loss," says a recent writer, "with 2 per cent., or with 4 per cent., of dilute acid, and only the fractional portion of a single part, as shown in the total degradation from all causes.

"The comparisons in Dr. Frankland's table of experiments, whilst they point out the Portland, Whitby, Hare Hill, and Park Spring, as the natural stones best adapted to withstand the influences of town atmospheres, indicate Ransome's patent concrete as equal to the best of these in its power of resisting atmospheric degradation; and the newness of Ransome's stone—the specimens experimented upon not have been made a fortnight—being taken into account, together with the fact that its binding material—silicate of lime—becomes harder and more crystalline by age, having led Dr. Frankland to express the opinion that it is likely 'Mr. Ransome has invented a material which, with the exception of the granite and primary rocks, is better capable of giving permanency to external architectural decorations than any stone that has been hitherto used.'"

11. The following is the table referred to in the above:—

Name of Stone.	Porosity per-centage of water absorbed by stone.	Per-centage alteration in weight by immersion in dilute acid.						Total per-centage loss by action of acid and subsequent boiling in water.	Further loss by brushing.	Total degradation from all causes.
		Of 1 per cent.		Of 2 per cent.		Of 4 per cent.				
		Loss.	Gain.	Loss.	Gain.	Loss.	Gain.			
Bath, . .	11·57	1·28	...	2·82	...	2·05	...	5·91	·26	6·17
Caen, . .	9·86	2·13	...	4·80	...	·67	...	11·73	1·60	13·33
Aubigny, .	4·15	1·18	...	4·00	...	...	1·04	3·56	·29	3·85
Portland, .	8·86	1·60	...	1·10	...	1·35	...	3·94	·24	4·18
Austen, . .	6·09	3·52	...	3·39	...	3·11	...	11·11	·27	11·38
Whitby, . .	8·41	1·07	...	...	·53	none	none	1·25	·18	1·43
Hare Hill, .	4·31	·75	...	...	·60	none	none	·98	·15	1·13
Park Spring,	4·15	·71	...	...	·10	·15	...	·81	none	·81
Ransome's Patent, .	6·53	...	·95	none	none	none	none	·63	·31	·94

12. As artificial stones may be classed *terra cotta* and the various kinds of cements known as *hydraulic cements.* Of these a brief description will be useful.

13. *Terra Cotta* is formed of various plastic clays, kiln burnt, till they are of sufficient hardness. This is a cheap material, and affords abundant facilities for being moulded into any desired form. Terra cotta is, in point of fact, a brick, but of a superior quality, being made of fine clay, and mixed with the dust produced by grinding or crushing pottery ready made. Although, when burnt, it possesses a far less absorbent surface than brick, still it is subject to cracks and flaws, which admit the atmospheric influences, and cause it to decay.

14. *Hydraulic Cements* possess the property of hardening, immediately after preparation, in water, or in damp air, or exposed to rain. The base of all cements of this kind is a carbonate of lime, combined with a silicate of clay. This foreign substance is found in all the stones which are known as cement stones, under the names of "septaria," and other nodules, and which are obtained in the "London clay at Harwich, or the Kimmeridge clay in Dorsetshire, or the lias in the Midland Counties and the north, or the mud of the Medway and the Thames." When these materials are burnt, the limestone is converted into lime, and the "condition and proportion of the foreign material determines the value of the resulting cement. In the process of *setting*, the lime first mixes with water, and becomes hydrate of lime, and is then rapidly converted into silicate of lime, adhering strongly in thin films to itself, and to foreign bodies with which it is in contact." Cements are sold under a great variety of names—the Roman, Parker's, Atkinson's, Medina, and Portland, being the best known. Roman and Parker's cement are made from the "nodules of calcareous matter found in the Lurden and the Oxford and Kimmeridge clays. Atkinson's cement is made from the lias; Medina from the Hampshire septaria.

15. The most important of the cements is the Portland, so called from its resemblance in colour to the well-known Portland stone. It is formed by mixing in definite proportions carbonate of lime with the argillaceous deposit of some rivers, the waters of which flow over clay and chalk. It is a cement of very great cohesive strength, having a strength nearly four times greater than that of the ordinary hydraulic cements. When mixed with broken bricks it forms a very strong concrete. When well made, this cement seems to be even stronger than Portland stone; thus, a block of cement was pulled asunder by a force of 2,280 lbs.—a similar block of stone required only 1,480 lbs. to fracture it. At the Great Exhibition of 1851 a most interesting set of experiments was carried out to test the strength of this cement. "The principal experiment was the breaking of a beam constructed of ten courses of hollow bricks cemented together, the upper part with three courses on edge and four on the flat, the lower two on edge and one on the flat. They were put together with Portland cement, and strengthened with hoop-iron bands $1\frac{1}{2}$ inch broad and $\frac{1}{16}$th of an inch thick. Fifteen of these iron hoops were inserted. The following were the dimensions of the beam:—

	Feet.	Inches.
Total length, . . .	24	4
Length between bearings, . .	21	4
Depth, ...	4	6
Thickness at bottom, . . .	2	3
Ditto at top, . . .	1	6

The total weight of the beam, including 1,200 bricks, 32 bushels of cement, and 32 of sand, was 17,150 lbs. 672 lbs. of stone were placed at the top of the beam. The weight of the attached scale was 1,792 lbs., and the suspended portion of beam 15,000 lbs., making the total suspended weight 17,464 lbs. The total sectional area cemented was 700 square inches, and the depth of the beam being $52\frac{1}{2}$ inches, the measure of its strength was $700 \times 52\frac{1}{2} = 36,750$ inches. For some months the beam was unsupported, carrying the weight as above stated—17,464 lbs. A weight of 15,000 lbs. was loaded on the beam at the centre; the loading was continued after some days till it reached the amount of 41,000 lbs., which caused a deflection of nearly four-eighths of an inch; 41,600 lbs. caused two cracks on each side of the fourth brick from the centre, and not long afterwards a crack exactly in the centre. On the addition of 10,000 lbs. to the load, the piers were affected, as shown by the breaking of a string which was stretched from one end to the other, and attached to the piers to measure the deflection. This weight caused the crack to extend through the six lower courses, and increased the deflection to $\frac{5}{16}$ths of an inch. The weight being increased to 62,800 lbs., which was borne for a short time, all the fissures widened, the centre crack extending vertically alike through cement and bricks; the piers were ultimately thrust a considerable distance out of the 'plumb,' and the beam broke into two parts.

"The beam tested with Roman cement was of the ordinary stock bricks banded as usual, bedded and jointed with cement, composed of equal proportions of best Roman cement and clean Thames sand. In this beam there were nineteen courses, the thirteen upper ones being two bricks deep, and the six lower ones $2\frac{1}{2}$ inches, fifteen bands of hoop iron being inserted, $1\frac{1}{2}$ inch broad and $\frac{1}{16}$th of an inch thick. The sectional area was 1,107 inches, the distance between the bearings being 21 feet 4 inches. After having been built for three months it was loaded with a weight of 11,200 lbs., suspended as usual from the centre. At the end of another period of three months the weight was increased 24,000 lbs.; after twelve months it broke down with a weight of 50,622 lbs."

16. Ransome's *Silicious Stone* remains to be noticed. This is made by working up sand and mineral substances with the fluid silicate of soda, exposed to a high heat in a kiln. The following chemical action takes place:—The alkali of the silicate of soda combines with an additional quantity of silicate in the sand, and is converted into a soluble glass, which binds firmly all the materials together in a solid mass, not liable to contraction or cracks. The following is a statement by Professor A. Ansted, who has devoted much time to the subject of building materials, *as to the resistance of the weather offered by terra cotta, cements, and silicious stone*:—"1. *Terra cotta*, contracting irregularly in the kiln, is subject to cracks and flaws, into which water penetrates, and expanding during frost, a peeling and splitting of the material naturally follows. It is almost certain, from the nature of the case, that delicate and ornamental work should be more liable to such injury than straight work and plain surfaces. 2. *Cement*, owing to the want of homogeneity in the raw material, is also very subject to flaws and cracks, and is injured by damp and frost like terra cotta. Both terra cotta and cement require painting in London and elsewhere. 3. *The silicious stone* is rarely flawed in the kiln; but even if it is, the stone does not crack, or the surface peel by exposure to damp and frost, owing to the nature of the cement, which is, in fact, glass. It is also worthy of remark that this material obtains its greatest hardness before it leaves the kiln, whereas cement gradually hardens, and continues to harden for many years, if it is not destroyed before the induration is sufficiently advanced."

17. Brick.—Little need be said on this material, further than pointing out that as a building material it possesses far higher claims to notice than is considered due to it in some quarters, more especially in Scotland. The following remarks, which we contributed to the pages of the "Agricultural Gazette," may perhaps be worthy of perusal on this point:—"Of the various materials employed for walls, none combine so many of the essentials necessary to secure good construction as brick. It is easier to set up, admits of good joints being secured, and gives rise to none of the vacuities observable in rubble walls, which harbour mice and rats, so annoying to the farmer, especially in the steading, and is less liable to atmospheric influences than stone. An inspection of a vast number of houses in England and Scotland has gone far to convince us that the employment of brick in Scotland would lessen the number of damp houses there so often met with; for it is a notorious fact, which even a most cursory inspection will show, that there is a much higher proportion of damp houses of stone in Scotland than amongst brick houses in England. Nor is this to be attributed to the difference of the climate. Some districts of Lancashire, not a hundred miles from Manchester, enjoy a far more unenviable reputation for rain and humidity than many parts of Scotland, and yet there is a marvellously small proportion of damp houses met with in those districts—small compared with similarly humid districts in Scotland. . . . . Nor need the want of solidity be brought against brick walls; a well-built 9-inch brick wall will compare very favourably with a 24-inch stone wall, built in the wretchedly-scrimped honeycomb system, too often passed off as good work in Scotland. Neither, in view of the economical features of construction, is brick as a building material to be classed as low as it is in Scotland. Estimates for cottages of brick would contrast favourably with those of stone, everything else being equal in both cases. Not seldom have we heard astonishment expressed at the low rate at which good cottages, with ample accommodation and convenient fittings, can be built in England. . . . . It is easy to bring vague objections against brick houses as to being cold, and to indulge in jokes at the expense of their solidity; but it should be remembered that the winters of England are little less severe than those of Scotland, and the inhabitants of the former as keenly alive as to what constitutes household comfort as those of the latter country, and that the apparent thickness of Scotch walls does not always insure dryness or warmth." Much, of course, depends upon local circumstances as regards the use—and the prejudice in favour of the use—of brick or stone. Where stone is plentiful brick is not likely to be had in esteem, although it is worthy of note that brick, even in such districts, is becoming more and more used. Brick, as compared with many kinds of freestone, is not so absorbent of damp and wet; and it possesses this useful peculiarity, that even if once thoroughly wet it dries rapidly, while stone, under similar circumstances, remains wet and damp for a very long period.

18. Timber.—As the object of our Essay is more to draw attention to the modes in use for the preservation of timber than to give a description of the varieties and peculiarities of those in use for building purposes, we shall glance but briefly at these. The timber used for building purposes is principally obtained from the coniferæ, or cone-bearing trees, and known under the generic name of fir timber. The principal supply of fir timber is obtained from America and the North of Europe. Memel logs, Baltic battens, and American red and yellow pines, are well known in the trade. Ash and oak are valuable woods, and are much used in works where durability, and a capability to resist severe strains, as in machines and framing, are desiderated.

19. *Causes of Decay in Timber.*—The causes of decay in timber may be divided into two great classes; first, those which operate upon the living tree, and those which operate upon the dead, or cut timber. On examining the transverse section of a tree, we find it to consist of—First, the internal pith, or heart wood; second, the "medullary rays;" and third, the bark. The bark is divided into two parts; the external is called the "cortical texture," and the internal the "liber;" the function of the bark is to protect the inner wood from external injury. Between the inner portion of the bark, the liber, and the outer portion of the medullary rays, is a layer of mucous viscid matter, called the "cambium," which is supposed to supply with nutritious matter the plant during the process of development. The "medullary rays" commence at the sheath which surrounds the pith, and radiate regularly through the successive layers of the woody fibres. Of these layers one is formed every year, until, in process of time, a series of concentric rings, or zones of timber, are formed. Each zone consists of two parts, one of which is hard and horny, the other soft and open in texture. The mode in which these portions of each zone, or ring, show themselves, exercises an important influence upon the value of the timber for building purposes; thus, if the horny part is very pronounced—that is, easily observable from its decided nature—the timber will be valuable in cases where it is to be subjected to violent strains. Although the horny part is dense and thick in timber of the best quality, it is considered practically to have the effect of causing shrinkage and warping to such an extent as to impair its value for cutting into planks. It is important to cut timber before it has reached its full period of growth, as, after the tree ceases to grow, the heart-wood begins to decay, and to give rise to what are known technically as "star shakes," there being cracks radiating from the centre to the outside of the tree, at which point the width of the cracks is greatest. In growing trees another cause comes into operation, reducing sometimes the value of the timber; this is supposed to be the action of vio-

lent winds upon the tree, which seems to have the effect of creating circular bands, which separate the successive layers of the wood. These open bands are termed "cup-shakes." In some cases these circular bands are soft and spongy in texture; wherever this is the case it reduces the value of the timber, as it will speedily decay in the buildings in which it may be used. Trees are also affected by lightning, the growth of fungi upon their bark, and by insects. When branches are rudely separated from the bole, or trunk of the tree, in such a manner as to make hollows in which rain may lodge, or fractures on which the atmospheric influences may act, decay begins, which is apt to spread to other portions of the tree. The knots thus formed in the timber are known as "druxy knots;" when of a foxy colour they are most dangerous; if decidedly black, the decay will not probably extend far into the tree. We have thus briefly glanced at the causes of decay or deterioration in the strength and value of timber which come into operation during the period of its growth; we have now to describe those causes which come into operation after the timber is felled.

20. From what has been already stated, it will be evident that the time of felling the tree will exercise some influence upon its strength and value. Various opinions, and many of them more or less contradictory, have been put forward on this point, but practically the period between October and April is that chosen for cutting timber in this country. One very important cause of decay in felled timber arises from an organic decomposition of the wood, produced by changes in the condition of the sap which abounds in it when felled. As soon as the albuminous portions of the sap are placed under condition favourable to the change, as warmth, the putrifactive process commences, and the decay goes on. The "seasoning" process which all timber goes, or should go, through, has for its object the getting rid of this sap. Timber, however well-seasoned, or altogether unseasoned, is liable to another cause of decay; this is known as the "dry rot." This is supposed to arise from the growth of several species of fungi. Under their influence the timber is rapidly reduced to a dry powder, which is easily rubbed off. Another cause of decay is the "wet rot," of which, Mr. Burnell says, although the most general and fatal, it is singular that it attracts less attention than the dry rot.

21. *Modes of Preserving Timber.*—The *seasoning* of timber, to which we have in the last paragraph alluded, is carried out by one of three methods—*natural seasoning*, *water seasoning*, and *artificial* or *hot-air seasoning*.

22. *Natural seasoning*, as its name imports, consists in placing the timber which is cut into balks and planks, in such conditions that a free circulation of air is secured, while it is kept from the action of rain. This is effected by piling the planks, or timber, under sheds, care being taken to have the timber dried as uniformly as possible, for wherever it is dried in one part more than another, warping and shrinking are sure to ensue. To get the full effect of this seasoning process, the timber should be subjected to it for at least two years. It is understood to be well seasoned if it has lost one-fifth of its weight.

23. *Water seasoning* consists in putting the timber in water, which serves as a vehicle for carrying off the sap—a principal cause of decay in timber. The longer the time timber is subjected to the action of water, the more quickly, as a rule, does the timber dry and get seasoned when taken out of the water. Thus, it is a well-known fact, that the fire-wood in Paris, which is brought down by and taken out of the river, dries quicker, is less green, and burns brighter than the wood brought to town by boat or rail. By good authorities the phenomenon is of the same nature as that which causes the Exosmose and Endosmose, discovered and explained by the naturalist Dutrochet. The water in which the timber is placed being lighter than the sap, the latter, being the denser, gives way to the water, which takes its place, the sap, with its fermentative principles—the cause of the decay—passing off into the water. Fresh or brackish water is alone useful for water-seasoning; sea-water—approaching in density to that of the sap—not being fitted for the purpose. Timber, as a rule, will be seasoned in fresh water if kept for two years, the water being *frequently* changed; while three years will be required in brackish water, the water being *continually* changed.

24. *Artificial or Hot-air Seasoning.*—Timber, especially the harder and denser qualities, are very frequently long in seasoning; this is owing partly to the wood being inaccessible to heat, so that the sap goes off in a tedious process of slow evaporation, and partly owing to the narrowness of the channels, or density of the wood, which prevents the free vaporization of the sap. Artificial heat obtained in ordinary drying-stoves, or by machine-propelled hot air, is therefore used to season timber. Perhaps the desiccating process of Messrs. Davison & Symington is the most successful which has yet been introduced. "The timber to be seasoned is placed in a chamber, into which currents of heated air are forced by means of a fanner worked by a steam-engine. So complete is the seasoning, that a violin, which had been in use for many years, when subjected to the desiccating process, lost a considerable per-centage of its weight. (See Essay on Warming and Ventilation for an illustration and description of a new hot-air fan invented by Mr. Davison.)

25. *Preservation of Timber.*—The readiest way to resist the attacks of dry and wet rot is to have all timbers placed in such situations that a free circulation of air can be maintained around it, and that an easy examination can at all times be made. The advantages of having the air to freely circulate around timbers are well seen in the open roof timbers of old churches, &c., which, being freely exposed to the air, are as sound nearly as the day when they were put up. A warm, damp, and stagnant air surrounding timber will almost inevitably cause decay.

26. Many processes have been recently introduced, by which the chemical changes going on in the tissues of the wood are resisted. These have all for their object the injection of a substance which, in the words of Mr. Burnell, "should at once precipitate the coagulable portion of the albumen retained in the tissues of the wood in a permanent insoluble form, which should not hereafter be susceptible of putrefactive decomposition. For this purpose many substances, many solutions, have been employed with variable success, of which the most important and the best known are—1. Kyan's patent, or the injection of a solution of the chloride of mercury. 2. Margary's process, or the injection of a solution of the sulphate of copper. 3. Sir William Burnett's process, or the injection of the chloride of zinc. 4. Payne's process, or the production of a double decomposition in the pores of the wood, by firstly injecting a metallic solution, such as the sulphate of iron, and then injecting a second solution, such as the carbonate of soda, which would form an oxide of iron in the cellular tissues. 5. Bethell's process of creosoting, or the injection of the heavy oil of tar; and Boucherie's process, which is, perhaps, rather a modification of the manner of injecting the sulphate of copper than the application of a new solution, although he occasionally uses the chloride of calcium and the pyrolignite of iron. The experience furnished by the railway system, and the various hydraulic works of our own and foreign countries, appears to me to have shown that the efficacy of those various processes may be described as follows:—The creosoting one is the most generally successful; the application of the sulphate of copper is successful in many cases; the other processes,

although, no doubt, of occasional value, have practically been abandoned." The great objection to the use of creosote in the preservation of timber used in *house-building*, is the offensive odour which it gives to it—an odour which, however, has the advantage of preventing the attacks of insects. The mode of preserving the timber by an injection of the sulphate of copper, the chloride of calcium, and the pyrolignite of iron, has therefore been recommended as the best for house-building purposes. Perhaps the most ingenious, if not the most successful, way of injecting these substances into timber, is that invented by Boucherie, of which the following is a description:—

"This process consists essentially of impregnating the wood with a preservative solution. The solution which is found to answer best is sulphate of copper, or the blue vitriol of commerce, one by weight of which is dissolved in 100 by weight of water. The peculiarity of the process, however, consists in the method of impregnating the wood with a solution—a method which is simple, and easily and inexpensively carried out. The method has two objects in view—one, the impregnating of the wood with the salt, and one the driving out of the natural sap, the salt taking the place of the sap. This latter constitutes not the least valuable part of the process; for in other systems the sap—the fermentation of which is the chief cause of decay in wood—is allowed to remain, while the Boucherie process expels it thoroughly, cleansing the tubes, or pores, from all fermenting matter. The importance of having the sap of timber expelled, and its place occupied by the preserving solution, has long been recognised; and attempts have been made to secure the advantages of this mode of treatment, but the expensiveness of the methods proposed have completely precluded all prospect of their being generally adopted. It has remained for M. Boucherie, as the result of many years experimenting on the nature of woods, to introduce a mode as simple as it is ingenious and philosophical. The long series of experiments which M. Boucherie instituted, resulted in proving that, although the structure of trees is tubular, there is no *lateral* communication between the tubes. To show how completely isolated each tube is from the other surrounding it, and how perfect is the *longitudinal* connection of the tube, M. Boucherie has shut off certain tubes at one end of a tree, leaving these exposed to form a certain word, and, by means of a coloured liquid forced along the tubes, has transferred the word, or name, from the one end of the tube to the other. And so completely is the flow of the liquid through the tubes carried out, that at whatever part of the tree a section is made, there the name is found. The following is the method of conducting the process:—'Soon after the tree is felled a saw-cut is made in the centre, through about 9-10ths of its section. The tree is then slightly raised by a lever, or wedge, at its centre, and the saw-cut is then partially opened. A piece of string is then placed round the saw-cut, close to the outer circumference of the tree; the support is then withdrawn, and the saw-cut closes on the string, thereby making a water-tight joint. An augur-hole is then bored obliquely into the saw-cut. . . . A wooden tube is then driven into the hole, the conical end of which is attached to a flexible pipe, which is in connection with a cistern, or reservoir, at an elevation of from 30 to 40 feet above the tree intended to be preserved. In the case of very long trees the foregoing method is slightly modified. When the timber is under operation, the sap runs out from the ends in a clear stream, showing the amazing quantity of this fluid which it contains; in fact, the preserving fluid will traverse a tree 12 feet in length with less pressure than is required to force it laterally through a plank three quarters of an inch in thickness. As the sap is forced out the preservative fluid follows it, and its presence at the ends of the wood is ascertained by a chemical test. Thus, the sap and fermenting juices are completely expelled, and the timber impregnated throughout its length with the preserving fluid.'"

27. A very ingenious adaptation of an old-fashioned mode of preserving timber has been recently introduced with great success in France, where it is used for the preservation of the timber used for the construction of ships. The following is a description of it, taken from a pamphlet by M. de Lapperant, Inspector-General of the Timber for the French Navy:—

"From time immemorial it has been the practice, particularly in the country, to burn the ends of the poles driven into the ground, to preserve them from decay. According to the sage remark of the celebrated Carlomb, we should always take into serious consideration old and well-known customs, but in this instance it is easy to admit the preserving effect of carbonization. In the first place, the surface of the timber is subjected to a considerable heat, the primary effect of which is to exhaust the sap of the epidermis, and to dry up the fermenting principles, here this is done by long exposure to the air; and in the second place, below the outside layer, completely carbonized, a scorched surface is found, that is to say, partly distilled and impregnated with the products of that distillation, which are creosoted and empyreumatic, the antiseptic properties of which are well known. . . . .

"The methods of carbonization which the author first employed at Cherbourg, and which, by the order of the Minister of Marine, are about to be extended to all the dock-yards of the French empire, are free from these objections, and realize, on the contrary, all the conditions to be desired, whether of simplicity, facility, safety, or economy. They are as follows:—

"A gas-pipe is brought into the dock-yard, an india-rubber tube is screwed on; the other end of which, furnished with a joint, should be fixed at the side of the bench at which the men work. To this joint another end of a tube of sufficient length is fixed, and on that a little brass end is placed, similar to that of a fire-pump, but having inside a small pipe communicating with the reservoir of a foot-bellows on the bench. The object of this bellows is, first, to mix with the gas the air necessary to obtain a complete combustion; and in the second place, to impinge on the jet of flame such a force that it may be directed every way, and made to act, not only on the surface of the wood, but in the holes, joints, bolts, mortices, &c., and in general, on every part of the timber. The combustion takes place with the most perfect regularity, and, as can be proved, without the least danger, which, be it understood, does not exclude the precautions commonly prudent to adopt whenever fire is employed, either on shipboard or in the dock-yard.

"The results obtained from experiments at the gasometer at Cherbourg, with the aid of a meter, and using a jet of average force, are—

"1st. That the consumption of gas would be about 200 litres per square mitre, or 200 gallons per 10 square feet of carbonized surface.

"2dly. That a workman, in an average day's work of 10 hours, would carbonize a surface of 40 square mitres, or 440 square feet.

"3dly. That one workman is sufficient for a bellows supplying two jets of gas.

"It may, therefore, be admitted, that at full work the expense would not exceed 15 centimes (1½d.) a square mitre, or 10 square feet. Besides, it has been ascertained by experiment, the operation can be facilitated by smearing, in the first instance, the surface of the timber with a little tar. By so doing these other advantages are gained:—

"1st. The carbonization of the cracks, that almost always occur on the surface of rough timber, is facilitated.

"2dly. It prevents the timber being affected too suddenly by the heat of the gas, which causes it to split.

"3dly. It prevents the cracking and splintering off of little ignited particles.

"But beyond a mere facing of tar we must not go; a little thicker layer would impede, instead of furthering the operation. Besides, we must stop as soon as the surface is freely carbonized, which shows that none of the parts below have escaped the charring, which is, I repeat, the end we seek. Under these circumstances, the depth carbonized will not exceed a third or a fourth of a millimetre. In ship-building the carbonizing process ought to be applied to every surface in contact with, or in general, intended to be surrounded by, moist stagnant air.

"Moreover, it will be advantageously employed in the graving-docks and slips, from the facility afforded in drying and hardening those parts of the hull intended to be preserved, and in destroying the fermentation which will be found there.

"In house-building, the process should be employed to the beams and joists imbedded in the walls, or surrounded with plaster; to the joists of stables, cow-houses, wash-houses, &c.—which, although exposed to the free air, are constantly surrounded by a warm and moist atmosphere, an active cause of fermentation—to the wainscoting of ground floors, to the flooring beneath the parquet work, to the joints of tongues and rabbets, &c.; for carbonization by means of gas still leaves to the wood for working purposes all the sharpness of its edges.

"By carbonization a practical and economical means is offered to railway companies of preserving almost for ever the sleepers, particularly oak, which cannot be impregnated by the injection of sulphate of copper. Let us suppose, for instance, that after, say 10 or 15 years, the sleepers on a line are taken up for the length of a mile, and replaced by new ones, the old, when rasped and burnt again, will serve for the replacing of the following mile, and so on, one mile after the other."

WARMING, VENTILATION, AND ARTIFICIAL LIGHTING.

1. These three things named above are desiderata which should be attended to in the construction and arrangement of structures, whether inhabited as permanent residences, or used for occasional occupancy by man, they play a most important part in his domestic and social economy, and minister greatly to his health and comfort, if not to the maintenance of the elegancies and luxuries of his life. It is, then, the duty of the engineer or architect, or of both, to see—when called upon to erect any domestic or public building—that all the arrangements, structural and otherwise, are such as are calculated to facilitate the carrying out of these three important departments, of what is now known as Sanitary Engineering or Architecture. It is for the reader "posted up"—as the phrase now goes, expressive if not refined—in all the details of this science, and acquainted with the art of construction as now exemplified around us, to say whether the structures of the present time are, or are not, calculated to give this facility. Possibly it is but the bare expression of a fact when we say that, as a rule, houses or public buildings are construced in defiance of all the principles which correct science—if, indeed, science is entitled to the name where not correct—indicates to us. Certainly we have not many instances to which we can refer as exemplifying correct methods of warming, ventilating, or lighting them. The rule, so far as domestic structures are concerned, is that no special means are taken to secure these three desiderata being economically carried out; and to this rule, so far as *public* structures are concerned, there are miserably few exceptions. Looking around us, would not an impartial review of our public and domestic buildings compel us to confess that it seems to be the opinion of those engaged in designing and constructing them that to warm, ventilate, and light them economically and efficiently are really not much required, and certainly are not essential in a sanitary point of view? If the contrary belief was held—not merely as a cold matter of opinion, but as a warm belief—surely some evidence would be given of it in houses well warmed, ventilated, and lighted. And yet few are met with amongst our practical men who do not at once give ready assent to statements as to the sanitary importance of these three requisites of "healthy homes." Yet how is it that they do not unite to carry them universally into practice? It is not for us here to answer this question—we put it simply, because, from its suggestiveness, it may be provocative of thought, and thought may induce action.

2. Taking it for granted, however, that our readers are alive to the importance of carrying out efficient warming, ventilating, and lighting, in all the buildings they may be called upon to erect, we proceed at once to detail, as clearly as the brief space at our command admits of, the principles which regulate sound practice, and some of the many methods by which this practice is carried out. Our paper, from the nature of its heading or title, naturally divides itself into three branches, each of which will be considered separately.

3. Warming.—Warming, so far as buildings are concerned, may be defined as the art of applying and economizing the heat which results from the combustion of fuel. When a body is heated by artificial means, or when we have a mass of burning fuel, the heat is given off to the surrounding air by two ways—firstly, by "radiation;" and secondly, by "conduction."

4. By *radiation* the heat is sent off from the heated body precisely as light is projected from a luminous body, that is, by rays which diverge in straight lines from every part of its surface. The intensity or heating power of these rays decreases as the square of the distance. The radiating powers of different materials are not uniform, but vary according to the nature of their surfaces. Thus, the material covering the surface materially influences the radiating powers of the heated body. Mr. Hood instituted some experiments which had for their aim the establishment of the influence of the colour or nature of the surface of cast-iron pipes. These were prepared in various ways; first, the pipe surface was left in the ordinary condition of pipes, covered with the usual coating of rust or protoxide of iron; second, it was varnished black; and third, painted white. Taking the cooling ratio of the black varnished pipe at 100, that of the rusted pipe was 103·3, and that of the white pipe was 105·7. To put this in another form, 100 feet of black varnished pipe, filled with hot water, will produce as much heating effect as 103¼ feet of rusted, and 105¾ feet of white painted pipe. Hence we see the practical benefit of having the pipes of heating apparatus blackened. The radiating powers of heated surfaces are also increased by roughening the surfaces. Radiant heat, it is necessary to remark, does not raise the temperature of the air through which its rays are projected, nor does the air re-act upon the radiated heat; a solid body must intervene before the radiant heat can be absorbed.

5. The heating of bodies by "*conduction*" is essentially different. When one part of a solid body—as the extremity of an iron rod—is raised in temperature, it communicates a part of this to another portion of the rod, and this again to another, until the whole of the rod is heated,—each part being successively acted upon, just as one link of a chain may be taken up after another till the whole is taken up. The whole surface of a body thus heated becomes available for obtaining a supply of warmed air. For the air, as it comes in contact with the surface, becomes warmed, and rising up diffuses itself in the surrounding atmosphere. Before, however, air can be heated thus in large quantities or volume, it is essential that a movement or current of it be established. Air in a quiescent state surrounding a heated body is in point of fact a retainer of heat, not a conductor of it. Air becomes a conductor only when it is allowed to circulate; the manner in which heat is imparted to it, and by which it imparts its heat thus obtained to the other particles of air, is in virtue of what is called the principle of "convection," which is called into operation when heat is applied to a mobile fluid, as air, gas, or water. Thus, as soon as the body of fluid next the heated

surface is warmed, from its great mobility it rises upward, imparting to the fluid through which it passes some portion of its heat. The place occupied by it is taken up by another body of the fluid. Thus, a complete circulation is kept up so long as there is a difference between the temperature of the fluid and of the body which heats it. "Conduction" and "convection" may thus be said to be synonymous terms, only that conduction is applied to solid, convection to fluid bodies.

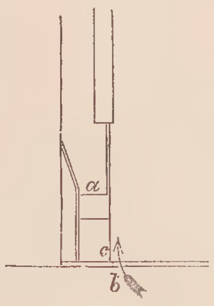
6. Having thus explained the way in which heat is communicated to bodies, we proceed to describe the methods by which this is made available in the practice of warming the interior of buildings. These may be divided into two great classes, each of which is susceptible of subdivision, namely — 1. Methods of warming, in which the open grate or fire-place is the principal feature. 2. Methods in which the heating or warming medium, as (1), burning fuel; (2), hot air; (3), steam; (4), hot water; or (5), gas, is contained within the interior of stoves, pipes, or other receptacles.

7. We shall take up first the consideration of an open fire-place or grate. It would be interesting, and instructive as interesting, to trace the history of the introduction of the open fire-place, but space prevents us doing this, however briefly. One thing would be very clearly deduced from this investigation, namely, that little real improvement has been effected till within a very recent period in the open fire-place. Defective grates are still the rule, and when we know that fully one-half of the heat is lost and passed up the chimney, we may well wonder that greater pains are not taken to introduce generally, a form of grate which will save a large proportion of the heat thus lost. We have said that one-half of the heat produced in an open fire-place is lost by passing up the chimney; this does not exhaust the causes of loss however, for about one-fourth of the heat *radiated* from the fuel into the apartment is drawn back again by the draught of air passing from the room into the chimney, and is thus lost. About one-eighth, then, of the amount of heat produced by the consumption of a given quantity of fuel is all that may be calculated on as utilized in warming an apartment by means of the open fire-place. Close stoves are much more economical, but prejudice—and we think it, upon the whole, a well-grounded one—is against these, and the cheerfulness of the open fire-place is therefore universally demanded in this country.

8. It is, then, of no small importance to have arrangements by which as much of the heat of a fire-place may be economized as possible, and to a few notes as to how this may be secured we now direct the attention of the reader. Those immediately following are extracted from the Essay on "Heat," published in the Cyclopædia of the "Architectural Publication Society of London," to which it was contributed by the author of the present paper:—

9. "In the fire-places of modern apartments in this country grates are almost universally used. The object in all such being to heat the lower portion of the hearth and surrounding substances, the bars should be placed very low. The consequence of this arrangement is that the floor and hearth being warmed, the cold air, which flows into the apartment in contact with them, is warmed by the ascending currents of heated particles. There should be provision made for admitting fresh air to the front of the fire-bars, not beneath them; as radiation is chiefly required from the front, the fuel there will be more quickly consumed by the fresh air being thus thrown against it. Another beneficial advantage derived from the use of this contrivance, or "blower," as it is called, is, that the currents of air along the floor, found in all apartments not having this plan, are dismissed. In fig. 1, showing the arrangement, the grate is indicated by *a*, the air-flue entrance at *b*, the position of the egress aperture, or blower, at *c*.

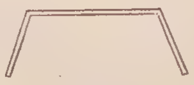
Fig. 1.



Position of Grate.

10. "The materials of which the bodies of grates are generally made militate very much against economy in their use; the desideratum is to have the fire surrounded by non-conducting materials. Iron should be sparingly used in parts near the fuel, and never allowed to surround the place in which it is actually consumed. Some manufacturers content themselves with leaving an aperture at the back of the grate on casting it, to be afterwards filled in with fire-brick; this is an approximation to what should be the law, yet it is not carried out to its fullest extent; the sides also should be filled in with fire-brick. A form of grate in which the fuel is carefully surrounded on the sides and back by good non-conducting material, is that known as the "fire lump grate," such non-conducting bodies could be easily applied to any size of grate by taking a model of its interior with a piece of block-tin. Fig. 2 is a plan of this body, having the sides of a proper angle at the back. In some grates, where the internal dimensions are too large, malleable iron sides, or "cheeks," are used to lessen the space and save the fuel; the above non-conducting body might for this purpose be substituted with advantage. As before mentioned, the chief effect derived from grates as generally used, is from "radiation." It is, then, of importance to construct them so as to have as large a surface of burning coal as possible presented to the interior of the apartment to be warmed. This will be best attained by making the breadth and depth of the front as large as convenient; while the breadth, from front to back, should be of the least dimensions consistent with the space requisite for steady combustion. A good proportion was found where the breadth from side to side of the front bars of the grate was fourteen inches, the depth, from the top to the bottom bars, was ten inches, and the width, from the inside of the top bar to the back of the grate, was six, but at the bottom four inches.

Fig 2.



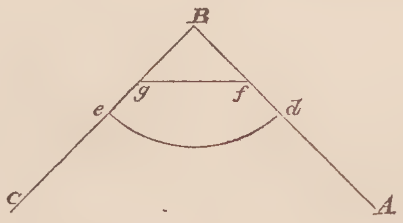
Fire-lump Grate Body.

11. "In order that the rays of heat may be readily and surely sent into the room, the sides, or covings, should be made at a certain angle, or curve to the back. The form in which the sides are at right angles to the back is the one worst calculated to throw out the rays of heat; *Guager** demonstrated very clearly the disadvantages of this form."

12. This demonstration we need not here give, preferring to insert Hood's method of adjusting the angle of the sides or covings. This is founded upon Count Rumford's recommendations to have the sides placed at an angle of 150° with the back of the grate.

13. "The sides," says Mr. Hood in his Practical Treatise on Warming Buildings by Hot Water, &c., "are a right angle of 90 A B C (fig. 3), and the bars describe a quadrant of a circle, whose

Fig. 3.



Mode of Setting-out the Covings of Grates.

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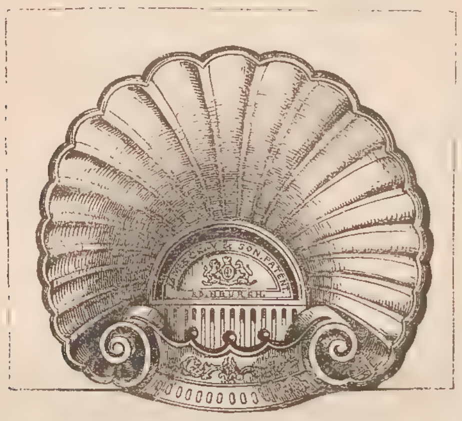
* Under the *nom de plume* of Guager, Cardinal Polignac published a treatise, explaining the principles on which he conceived fire-places should be con-

radius is just half the length of the side A B. If, now, we wish to follow Rumford's rule of making the back one-third the width of the front, we obtain this by taking one-third of the length A B, which will give B *f*; and then if we draw the line *f g* we shall obtain exactly the required dimensions. By this arrangement it will be perceived that the sides of the stove form an angle of 135° with the back, and all the rays of heat which fall upon these sloping sides will therefore be reflected into the room directly in front of the stove in right lines. The falling cover, or register-top, should also form an angle of 135° with the back, by which a large portion of heat will be radiated downwards into the room."

The forms of grates now introduced are often extremely elegant, combining every excellence of workmanship with grace of outline. A good example is met with in the radiating grate introduced by Messrs. Gray & Son of Edinburgh, and illustrated in fig. 4.

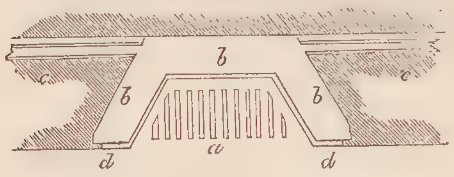
Fig. 4.



Radiating Fire-grate.

14. A very brief examination of the construction of the open fire-place will show that much of the heat must be passed by conduction to the surrounding materials. Louis Savot, in the seventeenth century, was the first to attempt to economise the heat thus lost, and to pass it to the interior of the apartment in which the fire-place was placed. Cardinal Polignac, in the treatise already alluded to, also described methods by which he used this otherwise waste heat. In these methods the principle was nearly the same, and may be illustrated by fig. 5, where *a* is the body of the grate, surrounded by an open space *b b*, supplied with air from the external atmosphere by conduits, or pipes, *c c*; the air, after being warmed, passing into the room through apertures in the front at *d d*.

Fig. 5.



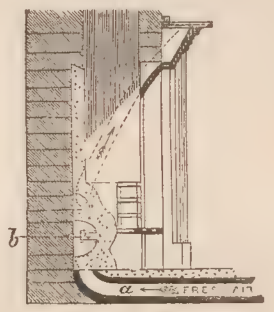
Warm Air Chambers behind Grates.

15. There are numerous forms of open fire-places now constructed on this principle. One well known, and held in high esteem is the fire lump grate of Mr. Pierce of 5 Jermyn Street, Regent Street, London.

"The principle upon which these grates are constructed, is that of using fire-lumps as the best and purest medium for the transmission of heat by radiation from the open fire, and the distribution of warm atmospheric air through the building. In consists chiefly of an open fire surrounded by Welsh lumps, which are perforated or hollowed out by vertical air passages; the whole is enclosed in an outer casing, which may be plain, or decorated in any style, or according to any taste; a channel communicating with the external atmosphere admits air to a cavity in the lower part of the casing, connected with the mouths of the vertical channels in the earthern lumps that surround the fire. The warmth which is communicated to the air through the body of these lumps, and which, from their small conducting power, can never be excessive, causes it to ascend through openings in the upper part of the casing into the apartment—*its place being supplied by fresh accessions of air from below. The warm air thus admitted into the apartment floats above, and gradually descends as it cools, and its place is supplied by warmer air from the stove-grate, and taking with it to the fire all the impurities of respiration, passing away by the flue, in which the heat maintains a constant upper current.* Valves are provided for regulating the quantity of air to be admitted in accordance with the temperature of the atmosphere outside."

16. Fig. 6 illustrates the arrangement of a grate on this principle; *a a* the pipe leading the fresh air to the vacuities behind the fire-lump (a species of fire-clay) *b*. Figs. 1, 2, and 3, Plate XXXIII., shows the form of Ventilating Fresh Air-grate, patented and introduced by Mr. W. Woodcock, manager of the Warming and Ventilating Company. This grate is set in a chamber, to which fresh air is admitted direct from the external atmosphere. When it is warmed it passes into the room through the apertures *a a* made in the front of the grate. Fig. 1 is a front elevation; fig. 2 is a vertical section; and fig. 3 a sectional plan taken through the line *a b* in fig. 1.

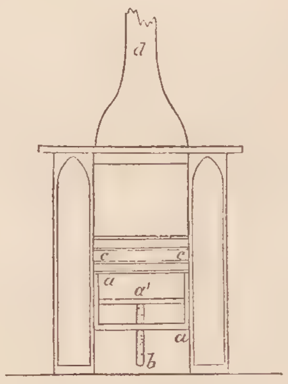
Fig. 6.



Pierce's Fire-lump Ventilating Grate.

17. Dr. Arnot, whose name is so honourably known in connection with sanitary science, has introduced a form of fire-grate which he terms his "smokeless grate," which authorities consider a very valuable arrangement. We illustrate this in fig. 7. The body of the grate *a*, in which the fuel is consumed, is square in form, and has a false bottom *a'*. It is made to slide up and down in its case somewhat after the fashion of a piston in a pump. Into this box the fuel is put, and in quantity sufficient to last a day's consumption. To the underside of the false bottom of the fire-box *a a*, a bar *b* is attached; this is provided with holes, or notches, so that by passing the end of the poker into one of these, the false bottom *a'* can be raised as desired. A ratchet catch maintains the false bottom of the box *a a* at any desired height.

Fig. 7.



Arnott's Smokeless Grate.

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structed. The work abounds in most valuable suggestions; many of them have been reproduced in modern and very recent times withal, without the introducers having troubled themselves much as to acknowledging the sources of their inspiration. Desaguliers published in 1716 a translation of this treatise under the title of "Fires Improved, or a New Method of Building Chimneys so as to prevent their Smoking, in which a small Fire shall Warm a large Room much better than a Large One made in the common Way." This translation is very scarce; it is, however, now and then to be met with on old book stalls. If any one of our readers should happen to see it on one of these, we give him two advices—first, buy it; second, read it. He will not, we venture to say. regret having followed them.

The coal or coke in the box *a a* is ignited by placing a layer of wood, and paper on the top, and above this a portion of the cinders left from the preceding day's fire. The wood and paper being lighted, the cinders ignite, and the heat, passing downwards, causes the gases and smoke to rise from the coal in the box *a a*; these pass through the wood flame and cinders, and become heated sufficiently to become flame, and so to augment the blaze. When the cinder is once fairly ignited, all the bitumen from the coal below rising through it afterwards burns, and the fire remains smokeless. As combustion of the fuel in the box *a a* goes on, the false bottom must be raised so as to raise the fuel up to the level of the fire-bars *c c*, so that air will be admitted to the mass of burning fuel. Further to economise the heat, and to save a portion of that usually passed up the chimney, Dr. Arnott contracts the chimney, forming it as shown in fig. 7, and at the narrowest part introduces a valve at *d*, by which the draught can be regulated at pleasure.

18. Before concluding the subject of the open fire-place we may be permitted to extract a few remarks on the setting of grates from the article in the Cyclopædia of the Architectural Publication Society already referred to.

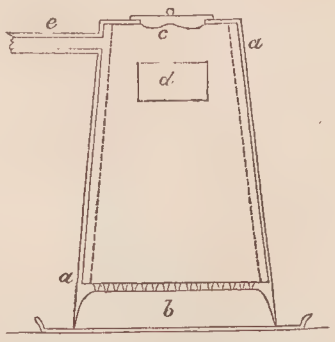
> "Grates should not be placed too far in under the mantel-tree; the outside bars may be flush with the outside of it. The practice of making the recesses for the reception of grates deeper than absolutely necessary should be at once condemned. The form of grates almost invariably used is that known as the "register," or similar construction. These, when placed in their receptacles, leave a large empty space between the back and the wall; this having often direct communication with the flue above serves the purpose of a deposit for all falling soot, which accumulates until it reaches that part of the back of the grate which is apt to be—in fact, is generally—highly heated, and combustion ensues.* It may be objected that the backs of grates are in some cases made of fire-brick, and that consequently the heat is not sufficient to cause ignition. Admitting the fact, the inference may be denied; it takes a much lower degree of heat to ignite so combustible a matter as soot than is generally supposed; and the result of all experience proves that this is the case. Again, sparks may be carried up the chimney and fall down amongst the soot; but all objections to an unlimited condemnation of the practice of leaving spaces behind grates are but poor and lame excuses for not getting rid of the absurdity. The use of a flue is to carry off the created soot, and that of a fire-place to heat the room; it is, therefore, as unphilosophical in principle as inducive of danger in practice to allow spaces to be left for the reception of what has no right to be there, or to construct grates in such a manner as to make it a *possibility* that inflammable substances near them may be ignited. . . . Iron chimney-bars, or bearers, ought always to be used in preference to those of wood, for one of the great desiderata to be attained in the construction of fire-places is the complete isolation of all the parts from the rest of the materials composing the edifice; and it need hardly be said that the further all wood work, whether plastered over or not, is from the grate or flue the better. All the joints should be carefully cemented; and if double brickwork be employed, the joints should break with one another. The chimney-vent, at its lower end, should communicate with the fire-place only, so that descending soot must of necessity fall into the grate. At the place where the flue commences immediately above the grate a valve opening upwards should be placed; this may be made of sheet-iron, hinged at one side similar to the register of improved grates."

To these remarks we may add that all grates should be *fixtures*, as much so as the doors of the house. The practice which obtains in Scotland of removing the grates at the expiry of each tenancy is an absurd one, and should be done away with.

19. We now come to the second division of the subject of Warming, which proposes to treat of methods in which the heating or warming medium, as (1), burning fuel; (2), hot air; (3), steam; (4), hot water; or (5), gas, is contained within the interior of stoves, pipes, or other receptacles.

20. Taking these in their order, we shall first glance at stoves, in the interior of which the burning fuel is placed, heating the outward case, and this, again, the air which comes in contact with it. The simplest form of stove is known as the Dutch stove, represented in fig. 8. This consists simply of a box or case *a a*, supported on feet or standards. The fuel rests on the fire-bars *b*, and is supplied to the stove either through an opening in the top, as *c*, which is covered with a moveable lid, or through the door *d* in the side of the stove. The smoke passes off by the flue *e*. There are very grave objections made to this form—first, the air coming in contact with the highly-heated surface of the stove is over dried; and second, the dull, miserable appearance which the apparatus presents in the apartment in which it is placed, having none of the pleasant cheerfulness of the open fire-place. The overheating of the iron of the stove may be prevented in some measure by lining it with a fire-lump or clay cylinder, as shown by the dotted lines in fig. 8. Again, the humidity of the air may be restored or maintained by having a dish of water placed on the stove; as this is kept heated the evaporation will go on *pari-passu* with the warming of the air as it comes in contact with the surface of the stove.

Fig. 8.



Stove Lined with Fire-brick.

21. The best form of stove yet introduced is, we think, that patented by Goldsworthy Gurney, Esq., and now brought before the public through the medium of the London Warming and Ventilating Company, 26 Great George Street, Westminster. In this stove all the objections against close stoves are met; the air is kept in a grateful state of humidity, and a large heating surface is obtained by very simple means. The main principle on which the stove acts is the correct one of giving large supplies of air moderately and healthily warmed rather than limited supplies over-heated, as is the case when the close stove, in fig. 8, is used. In fig. 9 we give an elevation, and in fig. 10 a vertical section of this form of stove. It consists, as will be seen, of a stove with a plain interior cylinder. The outer surface of this is not plain, but is provided with a series of projecting ribs, or wings, which add materially to the heating surface of the stove. The stove thus formed is placed in a pan of water, and so regulated as to produce the required amount of evaporation. The vapour thus produced passes, in conjunction with an ascending column of air, over the external surface of the stove, rising up between, and coming in contact with the surface of the ribs, or wings. The arrangement is such that the air is never "over-heated" or "over-dried;" and in consequence of the laws of convection a rapid intermixture of this warmed air takes place with that of the air in the apartment. A uniform temperature is

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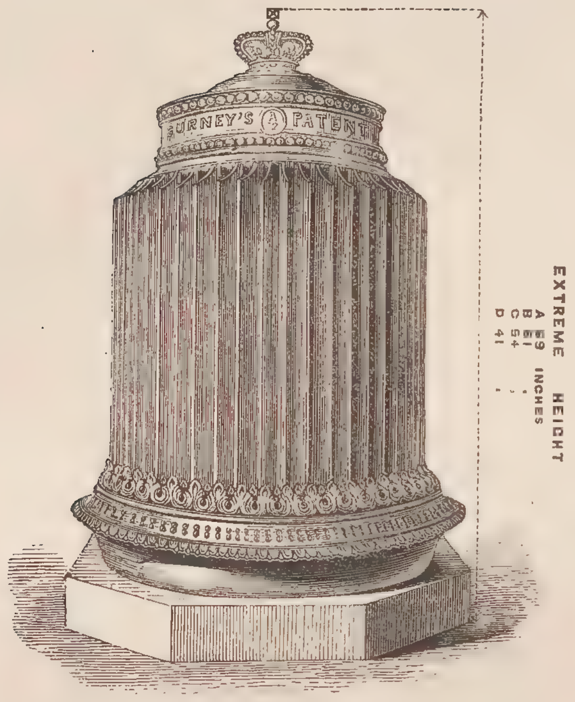
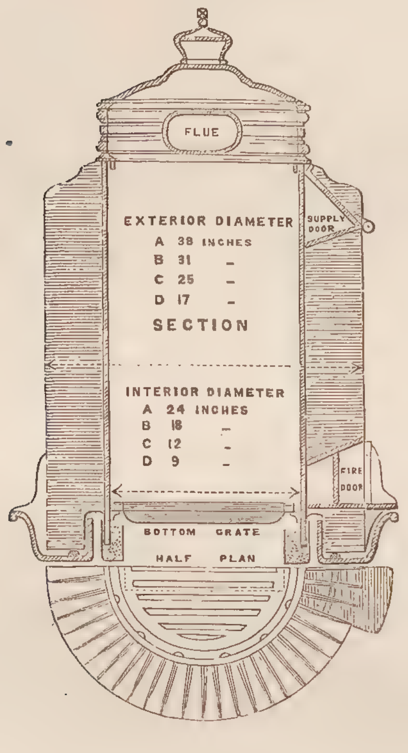
* The importance of this recommendation was once remarkably exemplified in the author's experience. Visiting a friend who complained that there was a continual smell of burning soot emanating from the drawing-room grate, and that the hearth-stone was getting rapidly and alarmingly heated, although everything had been done to ascertain the cause of it, it was nevertheless shrouded in mystery. The author at once suspected the cause, and getting the grate removed, exposed to view a large mass of burning soot, which, rapidly heating the surrounding materials, would soon have ignited the adjacent timbers. Still more recently, a fire broke out in the immediate neighbourhood of the dining-room grate of a town house; the cause was considered very mysterious. The author, who was consulted, saw no mystery in the matter.

Fig. 9.



External View of Gurney's Ventilating Stove.

Fig. 10.



Section and Plan of Gurney's Stove.

thus maintained in the room, even when the stove is placed at the extreme end of a long room. It will be observed on examining the drawings of the fresh-air grate in Plate XXXIII., fig. 3, that these wings, or ribs, are placed on the sides of the grate, as at *a a*, *a a*.

22. The American architects and builders have long been celebrated for their apparatus for warming the air of their houses, so essentially necessary in their severe winters. The forms are various, inventors having rivalled each other in the ingenuity as well as in the number of their appliances. Some, indeed many of them, are singularly defective in principle; but in the best of them special care is taken to secure large supplies of moderately warmed rather than limited supplies of overheated air. In large buildings the stove, or hot-air apparatus, is generally placed in the basement,—tubes, or pipes, leading the warmed air to the passages and apartments of the building. It is impossible here to find space for a notice of many of these stoves; we content ourselves, therefore, with a description of Chilson's apparatus, for which we are indebted to Mr. H. Barnard's work on "School Architecture," published in New York. In Plate XXXIII., fig. 14 is a plan, fig. 15 a vertical section of the apparatus, in which A A A are the outer walls; B B B space between outer and inner walls, two inches at nearest point; C C C inner wall; D brick covering over cold-air channel; E brick covering, or floor, from large entrance door; F F F F F iron trench-plates; G G G three four-inch brick piers support under trench-plates; H H space between trench-plates and base of fire-pot M for ingress of cold air; 4½ inches for Nos. 3 and 4; 5 inches for No. 5; and 6 inches for No. 6; I cast-iron ash-pit, or base to furnace; J cold-air channel; K set back, or recess in front wall. This stove is on the same principle as the "cockle," introduced in this country by Mr. Strutt of Derby, and much used before the introduction of steam and hot-water apparatus. The following remarks by the inventors of Chilson's stove, above described, contain some useful suggestions.

23. "The hot-air pipes should be conducted from the highest point of the inner wall, as in sectional view, through the arch of the brick-work, from which point they should gradually rise to the registers in the floor, always keeping in view the fact, that the nearer the pipes can be carried to a perpendicular line from the wall of the furnace to the apartment above the more readily and economically is heat obtained.

24. "The size of the pipes and registers, and their general disposition, is a matter requiring the best judgment of the mechanic under whose supervision they come, and are determined by the size, position, and distance of the apartment from the furnace, and cannot be subject to any fixed rule, as, in two rooms of the same dimensions we often use pipes and registers of different size, owing to their nearness or distance from the furnace in a horizonal line, their height above the basement, the relative position of other pipes, the purposes for which the rooms are to be used, and the amount of heat required, &c., &c. As a general rule, however, in rooms upon the *first floor*, whose dimensions are equal to 15 feet square, and of ordinary height, use an 8-inch pipe, and registers 8 by 12 inches; 20 feet square 10-inch pipe, registers 9 by 14 inches; 25 feet square 12-inch pipe, registers 10 by 16 or 12 by 19 inches. For halls of *ordinary* size use register 9 by 14, 10-inch pipe. Adopt the same scale in rooms of different capacity. If pipes, or hot-air tubes, are carried into apartments above those of the first floor, they should be 2 inches smaller in size than those used in rooms of the same capacity below; so that, should a lower room require a pipe of 10 inches in diameter, that above would be 8 inches, and still higher, 6 inches, supposing each room to be of the same size and directly above the first.

25. "In all hot-air pipes that go *above* the first floor, a damper should be placed near the exit from the furnace, and kept closed when not in use, in order to economise the heat that would otherwise fill the pipe when the registers are closed.

26. "It is often expedient to heat two adjoining rooms separated by a partition; in which case it is our custom to use but one pipe for both, bringing it up to the partition, and placing a T, or horizontal pipe, across the top, projecting each side, into which registers are to be inserted, of a size corresponding with the rooms.

27. "In double parlours, or rooms connected by sliding or folding doors, we usually place but one register near their common opening, in case it is intended to use both apartments at once.

28. "In many instances it is required to heat rooms not in a direct line of communication from the furnace, and in which it seems difficult to introduce pipes without marring the building, or exposing them to view in their passage through other rooms. In such cases an ingenious mechanic will generally surmount the apparent difficulty by taking advantage of closets, spaces between partitions, chimney-pieces, &c., or if either are impracticable, by carrying the pipe upright through the corner of the room and hiding its unsightly appearance by finishing in front with wood, and pointing it in representation of a column, or in such a manner as will best suit the style of the apartment. As a *rule*, however, we do not carry pipes above the first floor, except it is designed to heat an apartment for use during the day, as the heat from the hall register will keep the chambers comfortably warmed by having the doors opened.

29. The smoke-pipe should be carried directly to the nearest flue, and should it be necessary to carry it horizontally to a considerable distance, surround it by a casing, or pipe of tin, 3 inches larger in diameter than the smoke-pipe itself, and the waste heat that radiates from the smoke-pipe may be used to warm any adjoining apartment by continuing a hot-air pipe into the room, and inserting a *funnel register*, which we manufacture for that purpose.

30. "The cold-air box should be constructed of wood, smooth-planed inside and out. Its opening should be from the north or west side of the building; carry it along the ceiling to the furnace, then drop it per-

pendicularly down to the base of the cold-air channel. This box should contain a damper, or slide, which, in very cold weather, or when the fire is first kindling, can be *partially* closed, but so arranged that it shall never entirely shut out the air."

31. In fig. 8, Plate XXXIII., we illustrate another form—of much simpler arrangement—of hot-air apparatus. The arrangement shown is adapted for schools by Mr. Bishop, Superintendent of Public Schools in Massachusetts, U.S., and is intended to illustrate *two* plans:—

"In the first the cold air is admitted at (*a*), through the outside walls of the building, and descends in the direction described by the arrows to *r*, and thence rises to the top of the furnace, as shown by the arrows. At this place the cold air diffuses itself over the whole upper surface, about 8 feet by 10, and passes down between the double walls of the furnace in the spaces (*t*, *t*), which extend all around the furnace, and rises from beneath, through a large opening (*b*), into the air-chamber, where it is heated, and conducted to the rooms by large pipes (*f h*). The object of this mode of taking in air is twofold. In the first place, the constant currents of cold air passing over the top of the furnace keep that surface comparatively cool, and also keep the floors above the furnace cool, thus removing all danger of setting fire to the woodwork over the furnace.

32. "In the second place, as the inside walls are constantly becoming heated, and the currents of cold air, passing down on all sides of the walls, become rarified by their radiation, and thus, as it were, take the heat from the outside of the inner walls and bring it round into the air-chamber again at (*b*). This is not mere theory, but has been found to work well in practice. On this plan the outside walls are kept so cool that very little heat is wasted by radiation.

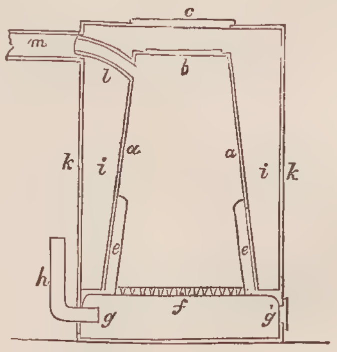
33. In the second plan the cold air is admitted as before; but instead of ascending from (*r*) to the top of the furnace, it passes through a large opening directly from (*r*) to (*p p p*) epresenting small piers supporting the inside walls, and thence into the air-chamber at (*b*), and also up the spaces (*t t*) to the top (*s*), from which the air, warmed by coming up between the walls, is taken into the rooms by separate registers, or is let into the sides of the pipes (*f h*). By this plan the air passes more rapidly through the air-chamber, and enters the rooms in *larger* quantities, but at a *lower* temperature. This is the better mode, if the furnace be properly constructed with large inlets and outlets for air, so that no parts become highly heated; otherwise the woodwork over the furnace will be in some danger of taking fire. The general defects in the construction of furnaces are:—*Too small* openings for the admission of cold air; *too small* pipes for conveying the warm air in all horizontal and inclined directions; and defective dampers in the perpendicular pipes. A frequent cause of failure in warming public buildings and private dwellings may be found in the ignorance and negligence of attendants."

34. The blank cheerlessness of the open stove, so much objected to in England, where the open fire-place is an "institution," has been attempted to be done away with in numerous forms of stoves, in which special arrangements are made to admit of the glare of the burning fuel in their interior to be seen. By this arrangement the cheerfulness of the open fire-place with the economy of the close stove is attempted to be attained. A very elegant form of this kind of stove has been patented by Messrs. Fowkes and Russell, and is illustrated in Plate XXXIII., figs. 4 to 7 inclusive. The invention consists in placing within an outer case, a fire-dish, or fire-basket, intended to contain the ignited fuel, and so suspended that rotatory motion may be communicated to it, whereby the fuel is worked about, and the ashes, &c., shaken down into the tray beneath. This arrangement is to prevent the fuel in the self-feeding conical receiver from sticking therein. Further, the invention consists in constructing the fire-basket with perforated sides, of openings, all round it, into which latter openings *talc* is inserted, so that the fire may be seen on all sides of the stove, and a cheerful appearance given to it.

35. An ingenious and efficient way of combining the cheerfulness of the open fire-place with the economy of the close stove is exemplified in the fire-place stove, of which, in figs. 16, 17, 18, and 19, Plate XXXIII., we give drawings. The plan here illustrated is that of M. J. Fournel of Liége, Belgium, and the drawings are taken from that constructor's work, entitled "L'Art du Fumiste," published at Liége, in which he describes the several methods employed by him for curing smoky chimneys, and constructing stoves and fire-places. The following is a description of the drawings in Plate XXXIII. Fig. 18 is the half plan in the line 5, 6, fig. 17; B B sides, or angular jambs, of glazed earthenware; C C the iron grate, or frame, for holding the fuel; I front of the grate; R R the sides and bottom of the grating, or bars; Q the ash-pit; P P P the conduit leading the fresh air from the exterior to the grate. Fig. 19 is half plan on the line 3, 4, fig. 17. X Y is the recess for fire-place; C C the iron grate; I the front bar; N the grating; M the short piece of vertical pipe or collar, cast on the body of the grate R R, fig. 18, and which carries the heating pipe, or battery, U V, figs. 16 and 17; F F brick sides, enclosing the battery seen in elevation in fig. 17 at F F. Fig. 16 is a vertical cross section of the grate in the line 9, 10, fig. 18; P P the conduit leading the air to the grate from the external atmosphere; R the body of the grate, carrying, at its upper and back part, a pipe, or collar, M, in which is inserted the tube, or heating battery, U V; D G pipes leading the hot air from the battery to the room—the air issuing to the room at each side of the fire-place; T the smoke flue. The other letters correspond with those of figs. 18, 19, already described. Fig. 17 is a longitudinal vertical section of the grate on the line 1, 2, fig. 18. D O O O G the pipes and elbows which lead the hot air from the battery U V to the sides of the fire-place, issuing at K—(part only of the drawing is given, the part not shown being merely a repetition of the part shown). E E E E bricks placed at an angle to form the throat of the chimney T.

36. The stove invented by Dr. Arnott, and generally called by his name, has long possessed a high reputation as an efficient and economical apparatus. The principle upon which it operates is to allow the fuel to burn very slowly, the admission of the air to maintain combustion being regulated by a self-acting regulator. Dr. Arnott claims for his stove, when *properly* constructed—a necessary reservation, seeing that very few indeed of the stoves introduced under his name possess the distinctive peculiarities of the original—that it never heats the air above the temperature of boiling water, the object being the maintenance of a medium uniform temperature throughout the whole apartment in which the stove is placed. Fig. 11 will indicate the arrangements of an "Arnott Stove" after the principle of the inventor. The fuel to be consumed is placed within the interior receptacle *a a*, which is conical-shaped, so that when a supply of fuel is placed in it through the door, or cover *b*—this being reached through the cover *c*—the fuel falls of itself into the grate *f* as fast as it is consumed therein. The grate *f* is surrounded with fire-clay *e e*; *f* are the fire-bars; *g′ g* the ash-box, which is furnished with an air-tight door *g′*. The air to supply the

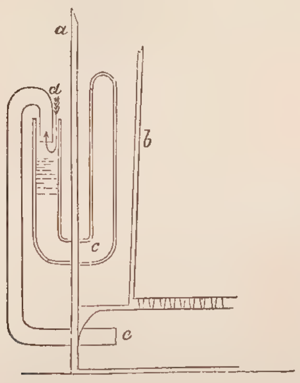
Fig. 11.



Arnott's Stove.

fuel is admitted to the ash-box *g g′* through the tube or pipe *h* alone; and to ensure the combustion of the fuel in the grate *f* being carried on slowly, the amount of air passing through the pipe *h* to the ash-pit is regulated by one of a variety of ingenious self-acting valves. One of these is shown in fig. 12. Let *a* be the exterior casing of the stove, *b* the interior casing containing the fuel, *c* the space between these. In this a tube containing mercury is placed, and passing to the external atmosphere it is bent upwards and left open at *d*. Into the open end the extremity of a tube dips, and is led down and into the ash-box *e*. Through this tube the air is admitted to the fuel in the box *b*. If the temperature of the air is low in the interior space of the stove, the mercury contracts and falls in the open leg *d*, and air is allowed to pass into the tube leading to the ash-box *e*. If the temperature rises in the space *c*, the mercury expands, and closes up more or less the opening of the tube, thus regulating the admission of the air to the ash-box *e*. The combustion, then, of the fuel in the fire-box *d* being carried on very slowly heats the air in the lower part of the case very moderately, and as it is warmed it rises in the interior space *i i*, fig. 11, and the colder air descends to be heated in turn, so that a continual circulation of the air in the space is kept up, and the exterior casing *k k* is maintained at a uniform temperature. Sufficient air is admitted by the tube *h* to maintain combustion merely, so that a comparatively small quantity of air escapes by the flue *m*—small as compared with the quantity circulating in the space *i i*. This stove is only really economical and up to the inventor's standard when the combustion is maintained at a very low rate, and the temperature of the outer casing is not higher than 212°. When, to obtain a quicker supply of hot air, the combustion is increased, the stove no longer possesses the features of excellence which the inventor claims for it. It is this neglect of the "principle" of its action that has brought this stove in many instances into disrepute.

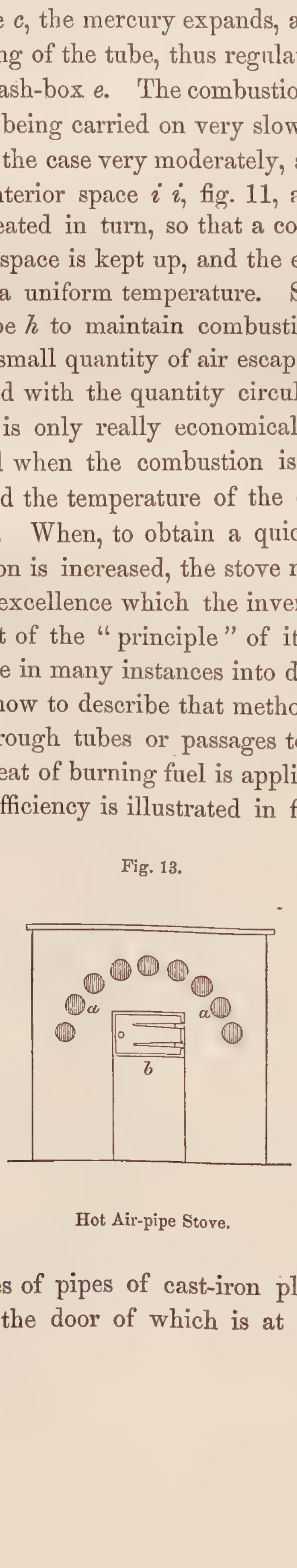
Fig. 12.



Regulator of Arnott's Stove.

37. We have now to describe that method of warming air by passing it through tubes or passages to the exterior surfaces of which, heat of burning fuel is applied. An apparatus of considerable efficiency is illustrated in fig. 13, where *a a* represent a series of pipes of cast-iron placed arch-fashion over a furnace, the door of which is at *b*. The air passes through tubes, and finally unite in a chamber at the other end of the furnace, from which it is led to any desired part.

Fig. 13.



Hot Air-pipe Stove.

38. A form of stove, with a descending flue, in which the air is heated by passing up the interior of tubes, is shown in figs. 20, 21, and 22, Plate XXXIII. This stove is designed by M. Fournel, and illustrated in his work "L'Art du Fumiste," alluded to in par. 35. In fig. 22 we give the half plan of stove on the line 5, 6, fig. 20; C door of the stove through which the fuel is supplied to the interior; R iron plate, or hearth of the stove. This is pierced with nine holes, A A A A, which carry vertical tubes, A A A A, in figs. 20 and 21; B the chimney flue. Fig. 21 is a longitudinal vertical section of the stove on the line 3, 4, fig. 22; R R the hearth of iron, carrying the tubes A A, up which passes the air in the direction of the arrows A A A A, the heated air passing out to the reservoir E, and from thence to the room in which the stove is placed, through the tubes O O D D; H is the conduit connected with the external atmosphere, supplying fresh air to the tubes A A, one of which is shown in section; G G G the smoke and heated air passages from the fire; these pass in the direction of the arrows *f f f*, and finally are led off to the descending flue B, and subterranean conduit U; T T upper part of the stove of marble; M M M circles, or bands of copper, which bind together the porcelain or earthenware sides of the stove. Fig. 20 is a transverse vertical section of the stove on the line 1, 2, fig. 22; D D D D the openings of the pipes leading the hot air from the reservoir E E, formed by the plates R R, X X; C door of stove; Q a lesser opening, in which a door slides between two grooves, and by drawing out or pushing in which the rate of combustion of the fuel may be increased or lessened as desired.

39. But by far the most efficient way of using air heated by its passage through tubes where large volumes are required, is that patented by Messrs. Davison & Symington, and illustrated in fig. 9, Plate XXXIII. An eccentric fan *a*, driven by a steam-engine, forces air through a series of pipes *a a*, *d d*, arched over a furnace *b b*. The air from the fanners *a* passes along the tube *c c*, up one side of *d d* and down the other, round the junction *e*, up and down *a a*, through *f*, and finally led off to the building to be heated. When a large building is to be heated this will be found a most efficient apparatus; the degree of temperature can be regulated with a great nicety.

40. We now come to steam-heating apparatus. We should only advise this medium to be adopted when there is a steam-boiler on the premises; as it does not present such marked advantages as to urge special apparatus to be erected for it Space, therefore, need not be taken up by going very minutely into the details of the apparatus required. Those of our readers who may be desirous of studying the matter fully may consult with advantage Tredgold's Treatise on Warming, or the article *Heat* in the Cyclopædia of the London Architectural Publication Society.

41. The additional space required in a steam-engine boiler for the necessary quantity of steam to warm a building may be set down at the rate of 1 cubic foot for every 2,000 cubic feet of space to be warmed. The usual way to use steam for heating the interior of a building is to pass it from the boiler to a pipe, which is led round the room. This is placed either on standards near the skirting-board, or within a conduit or open drain beneath the flooring, this being covered at intervals with open gratings, through which the heated air ascends. When this latter method is adopted, it is, of course, necessary to supply the conduit in which the pipes are placed with fresh air. The pipes should be inclined to the boiler, so that the water of condensation may easily be taken back to it. Where the return pipe is taken back to the boiler, returning the steam and con-

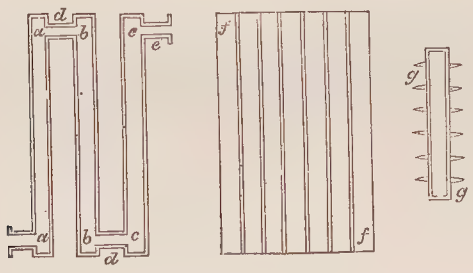
densed water to the boiler after the circuit is completed, a somewhat complicated arrangement of "trap," or valve, is required. To obviate the use of this, it will be the simplest way, if not the best, to allow the steam to pass from the pipe into the open air after it has made its circuit, and to have a pipe, with stop-cock attached, at the same place for leading the water of condensation to a small tank, or to the ordinary drain attached to the building.

42. In place of passing the steam through a long range of pipes, as described in last paragraph, a method susceptible of considerable elegance of arrangement will be found by encasing—at particular points of the building—one of the many varieties of pipe or chamber arrangements, taking care to bring to the interior of the casings a supply of fresh air. A few of these pipe or chamber arrangements may here be illustrated or described. A very common arrangement is having a series of pipes, to which the steam is admitted, placed one above the other near the wall, or in the centre of the apartment, as

o o o
o o o
o o o
o o o
o o o
o o o

These are encased within an ornamental covering, and all the pipes are connected one with another. In place of pipes, flat chambers are constructed of plates, leaving thin spaces, as *a a*, *b b*, *c c*, fig. 14, between them, into which the steam is admitted, one after the other, through the pipes *d d d*, and finally led off by the pipe *e*. To increase the heating surfaces of these plates, ribs, or wings, are cast on them, as shown at *f f* in elevation of one of the sides of the chambers, and in plan at *g g*. This is on the same principle as the ribs, or wings, on the stove illustrated in fig. 9. This latter stove, with steam supplied to its interior in place of having burning fuel, will form a very efficient and elegant mode of warming the air of an apartment.

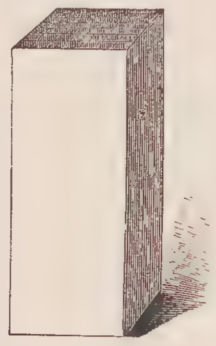
Fig 14.



Heating Surfaces.

43. Possibly one of the most compact forms of heating media is the "heat-box," patented by Mr. William Walker, the well-known warming and ventilating engineer of Manchester. This heat-box is made up of a number of cast-iron blocks, one of which is shown in fig. 15. Each block contains a number of square cells or tubes, both sides of the divisions between the cells forming effective heating surfaces. These blocks, usually six in number, are placed within a hollow case of an ornamental form, standing within a few inches of the ground. Steam, or hot water, is supplied to the space surrounding the case, and the heat is communicated to the blocks. The air passing up the interior of the cells becomes mildly heated, its place being supplied, and a continuous current maintained through any fresh-air flue over the mouth of which the set of blocks may be fixed. The blocks and their case—for the case itself forms a heating medium — "which may be denominated the honeycomb, or cellular arrangement," will present more heating surface to the air than can be obtained within a given space by any other form. The remarkable aggregation of heating power thus attained in a small space will be best understood when it is stated that in a heat-box measuring 27 inches long, 18 inches wide, and 16 inches high, 80 effective feet of heating surface are collected.

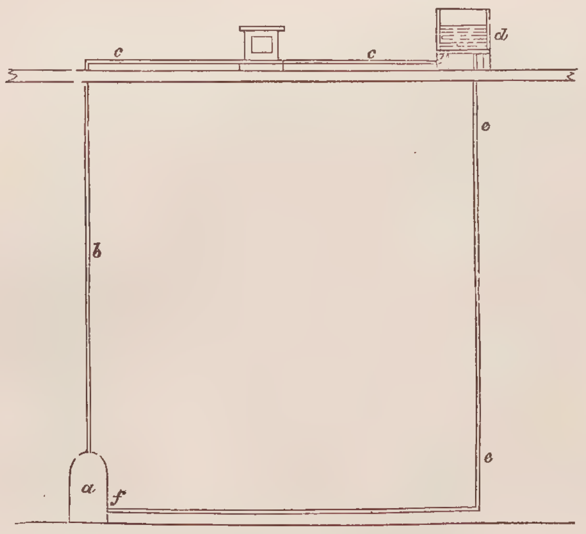
Fig. 15.



Walker's Heat-box.

44. The *hot water* apparatus now claims our attention. Hot water apparatus is divided into two classes—"low pressure" and "high pressure"—both depending upon their action on the law of "convection," which we have already, in paragraph 5, explained. When heat is applied to the lower part of a body of water contained in a vessel, as the particles of water at the bottom get heated they rise up towards the top, while other and colder particles descend to take their place, and getting in their turn heated, rise to give place to colder particles. Thus, a constant circulation is maintained till the mass is of a uniform temperature; but if the vessel, which we shall suppose a tube, is elongated, and a great portion of its length exposed to the atmosphere, which will rob it of its heat, this uniformity of temperature will seldom be attained, so that a continual circulation of the particles of water will take place in the tube so long as heat is applied to its lower extremity. This is what happens in the hot-water apparatus. Fig. 16 illustrates an arrangement of low pressure water apparatus, in which *a* is the boiler, *b* the ascending-pipe, which is led along the floor of the apartment *c c*, above that in which the boiler is placed, giving out heat to its atmosphere. The pipe *c c* enters at the lower part of a cistern *d*, from the bottom of which the return-pipe *e e* is led, entering the boiler at *f*. Congeries of pipes, or a heat-box, as explained in paragraph 29, may be placed at *g*, in the centre of the room.

Fig 16.



Low Pressure Hot-water Apparatus.

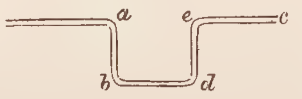
45. Mr. Walker of Manchester has introduced a form of hot-water boiler for the low pressure system, which may be called a hot-water stove, inasmuch as it not only is useful in warming the place in which it is fixed, but keeps up a supply of hot water, which may be led to other apartments. We consider the arrangement admirably adapted for heating halls, staircases, &c., &c. In fig. 10, Plate XXXIII., we give a vertical section of the boiler, in which *a* is the fire-box, *b* ash-

box, *c* smoke-box, *d* fire-bars, *e* smoke-tubes, *f* fuel-box, *g* damper, *h* flow-pipe, *i* return-pipe for the water, *j* ash-door and valve, *k* fire-door, *l* pipe to chimney, with valve or damper. Fig. 11 is front elevation; fig. 12 sectional plan through tubes; fig. 13 sectional plan through fire-box.

46. The following remarks on the fitting-up of low pressure apparatus will be useful:—

"In arranging the position of the pipes the points to be considered are—their distribution, so that each apartment shall be effectively heated to the temperature required; and their levels so adjusted that no air may accumulate in any part and impede the circulation. With reference to the first point, it will be seen that when the hot water is taken up at once to the supply-cistern, the descending-pipes will give out more heat than those placed in the lower apartments near the boiler, the water, by the time it reaches these, being deprived of a considerable portion of its caloric. The simplest method of effecting the desideratum in this case is, to have the hot water taken directly to the cistern, and led from this, by separate ranges of pipes, to the various apartments to be warmed, taking care to cover the pipes (with felt or other non-conducting materials) until they reach the place in which they are to give out heat. The circulation may be stopped in each range by having cocks attached at convenient places. The apertures in the cistern leading to the various ranges may be made conical, with corresponding plugs fastened to the sides of the cistern by chains. The various ranges should be numbered, and the plug apertures correspondingly marked, so that the desired range could be shut off at once by inserting the plug belonging to it. To prevent the accumulation of air in the pipes, air-cocks and pipes should be attached at the places where the pipes change their level. However small the descent may be, this should be carefully attended to, as a very slight alteration has often been found to render the accumulation of air so decided as nearly to destroy the usefulness of an apparatus, though in every other respect fitted up with the utmost care. If the air-vent were to be made at part of a pipe at *a*, fig. 17, the accumulated air would be withdrawn from *a b*, but none would be taken from the portion between *c e d*, as it would have to descend through the pipe *d b*, filled with water, which, as the air is lightest, is an impossibility. It is clear, then, that the difference of level, even of a short distance, should be attended to, half an inch militating against the working of an apparatus as much as half a foot. If the circulation in a low temperature apparatus be stopped, and there be any certainty that the pipes were carefully cleared out, and freed from all internal obstructions when fitted up, then the levels should be examined, and at every change air-tubes should be attached; if the air-tubes be carried to a level higher than that of the supply-cistern they will be self-acting, requiring no stop-cocks. The water with which to supply boilers is of some importance, that which is free from all carbonaceous deposit being best. If the apparatus be not used for a certain portion of the winter months, the water had better be taken out of the pipes lest the water freezing in them should burst them."

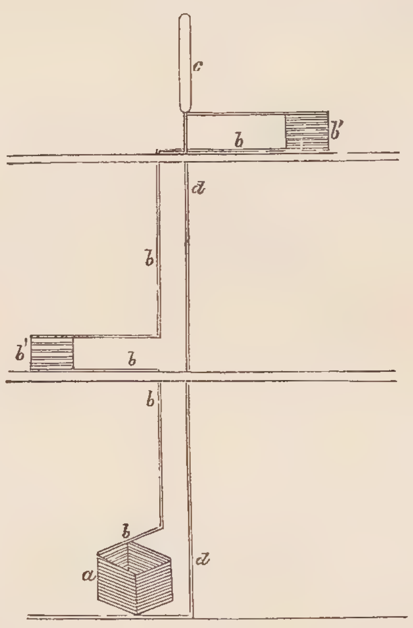
Fig. 17



Position of Pipes.

47. In the low pressure apparatus just described, the temperature of the water in the pipes can never exceed that of boiling water, so that no over-heating of the air is possible. In the high pressure system, now to be explained and illustrated, a temperature of 300° or 400° Fahrenheit can easily be attained. This apparatus, in its rudimentary form, is simply a pipe, hermetically sealed, and filled with water up to a certain level; heat being applied to the lowest portion of the pipe, the water is heated and expands into the empty part of the pipe. Practically, however, the arrangements are more complicated, although this gives a fair idea of the principle of the apparatus. Fig. 18 shows an arrangement: *a* is the coil of pipes which forms, in fact, the boiler, and is placed in the basement of the building to be warmed, which, as the illustration supposes, is of three stories; *b b b b* is the ascending, or flow-pipe; *b′ b′* show coils of pipe which warm the air of the apartments in which they are placed; *c c* the expansion-tube; *d d* the descending or return-tube.

Fig. 18.



High Pressure Hot-water Apparatus.

48. The size of the tubes or pipes of the high pressure is much less than that of those employed in the low pressure system. In the latter, two and three inches is the common size for dwelling houses, 4 inches for conservatories, &c.; in the high pressure system the diameter of the pipe is one inch externally and half an inch internally; the diameter of the expansion-tube, as *c*, fig. 18, is 2½ inches. To admit of the necessary degree of expansion the contents of the expansion-tube should not be less than one-tenth of the contents of the whole of the heating-tube attached; some allow as much as one-fifth; it certainly is better to allow an excess than a deficiency. A tube is specially connected with the apparatus for filling it; the entrance to this, of course, is placed at a higher level than that of the heating tubes.

49. It is a difficult matter to decide which is the best of the two methods—high or low pressure. Possibly the low pressure possesses the most easily carried-out features, and where carefully fitted up will give every satisfaction. By using such a form of boiler as in fig. 10, Plate XXXIII., and heating blocks, as in fig. 15, or the Gurney stove in fig. 9, the whole of them being easily fitted-up and perfectly independent of brickwork; the low pressure system may be carried out at comparatively little expense. Where the arrangements for warming a number of apartments are complicated, and the high pressure system is decided on, it is worthy of remembrance that perfect satisfaction will not be obtained unless the heating arrangements are planned and elaborated *pari passu* with the design of the building in which they are to be placed. To aid the reader in deciding on his choice of the form of hot water apparatus to be adopted, the following opinion of Mr. Hood—than whom there is no better authority on the subject—in favour of the low pressure system, may be useful:—"Owing to the smallness of the pipes in the high-pressure apparatus, the coil cools so rapidly when the fire slackens in intensity, that the heat of the building is materially affected by the least alteration in the force of the fire, instead of maintaining that permanence of temperature which is so peculiarly the characteristic of the hot-water apparatus with large pipes."

50. As a practically useful conclusion to this department of our Essay, we here give sundry rules connected with calculations as to the quantity of pipe required for heating apartments of definite dimensions. These refer to *steam* and *hot water*.

51. And first as to STEAM. The following is taken from Tomlinson's Treatise on "Warming and Ventilating," pub-

lished by Weale in his celebrated Rudimentary Treatises (p. 124). Warmth in a building is lost

(1.) "Through the thin glass of the windows; (2.) More slowly through the walls, floors, and ceiling; and (3.) In combination with the air which escapes at the joinings of the windows and doors, or through openings expressly made for the purpose of ventilation. The amount of heat lost in this way has been variously estimated by differrent writers; but Dr. Arnott states it thus:—That in a winter day, with the external temperature at 10° below freezing, to maintain in an ordinary apartment the agreeable and healthful temperature of 60°, there must be of surface steam-pipe, or other steam-vessel heated to 200° (which is the average surface temperature of vessels filled with steam of 212°); about 1 foot square for every 6 feet of single glass window of usual thickness; as much for every 120 feet of wall, roof, and ceiling of ordinary material and thickness; and as much for every 6 cubic feet of hot air escaping per minute as ventilation, and replaced by cold air. A window, with the usual accuracy of fitting, allows about 8 feet of air to pass by it in a minute, and there should be for ventilation at least 3 feet of air per minute for each person in the room. According to this view, the quantity of steam-pipe, or vessel, needed under the temperature supposed for a room 16 feet square by 12 feet, with two windows, each 7 feet by 3, and with ventilation by them, or otherwise at the rate of 16 cubic feet per minute, would be—

For 42 square feet of glass (requiring 1 foot for 6), ...	7 ft.
„ 1,238 feet of wall, floor, and ceiling (requiring 1 ft. for 120),	$10\frac{1}{3}$ „
„ 16 feet per minute for ventilation (requiring 1 foot for 6), .	$2\frac{2}{3}$ „
Total of heating surface required, ...	20 ft.

Which is 20 feet of pipe, 4 inches in diameter, or any other vessel having the same extent of surface,—as a box 2 feet high, with square top and bottom, of about 18 inches. It may be noticed that nearly the same quantity of heated surface would suffice for a larger room, provided the quantity of window glass and of the ventilation were not greater; for the extent of wall, owing to its slow conducting quality, produces comparatively little effect.

The same excellent authority also supplies the following illustrations:—"A heated surface, as of iron, glass, &c., at temperatures likely to be met with in rooms, if exposed to colder air, gives out heat with rapidity nearly proportioned to the excess of its temperature above that of the air around it, less than half the heat being given out by radiation, and more than half by contact of the air. Thus, if the external surface of an iron pipe, heated by steam, be 200°, while the air of the room to be warmed by it is at 60°, showing an excess of temperature in the pipe of 140°, such pipe will give out nearly seven times as much heat in a minute as when its temperature falls to 80°, because the excess is reduced to 20°, or $\frac{1}{7}$th of what it was. Supposing window glass to cool at the same rate as iron-plate, 1 foot of the steam-pipe would give out as much heat as would be dissipated from the room into the external air by about 5 feet of window, the outer surface of which were 30, warmer than that air. But as glass both conducts and radiates heat about $\frac{1}{7}$th slower than iron, the external surface of the glass of a window of a room, heated to 60°, would, in an atmosphere of 22°, be under 50°, leaving an excess of less than 30°, and about 6 feet of glass would be required to dissipate the heat given off by 1 foot of the steam-pipe. In double windows, whether of two sashes or of double panes, only half-an-inch apart, in the same sash the loss of heat is only about one-fourth of what it is through a single window. It is also known that 1 foot of black or brown iron surface, the iron being of moderate thickness, with 140° excess of temperature, cools in one second of time 156 cubic inches of water 1°. From this standard fact, and the law above given, a rough calculation may be made for any other combination of time, surface, excess, and quantity. And it is to be recollected that the quantity of heat which changes in any degree the temperature of a cubic foot of water, produces the same change on 2,850 cubic feet of atmospheric air."

52. Mr. Hood, in his valuable work on "Warming Buildings by Hot Water" (Whittaker & Co., London), gives some useful rules for calculating the quantity of pipes required to warm a building by *hot water*. After giving a series of data he proceeds thus:—

"From the preceding calculations the following carollary may be drawn:—The quantity of air to be warmed *per minute* in habitable rooms and public buildings must be $3\frac{1}{2}$ cubic feet for each person the room contains, and $1\frac{1}{4}$ cubic foot for each square foot of glass; and for conservatories, forcing houses, and other buildings of this description, the quantity of air to be warmed *per minute* must be $1\frac{1}{4}$ cubic foot for each square foot of glass which the building contains. When the quantity of air required to be heated has been ascertained, the length of pipe which will be necessary may be found by the following

"Rule:—Multiply 125 by the difference between the temperature at which the room is purposed to be kept when at its maximum and the temperature of the external air, and divide this product by the *difference* between the temperature of the pipes and the proposed temperature of the room; then, the quotient thus obtained, when multiplied by the number of cubic feet of air to be warmed *per minute*, and this product, divided by 222, will give the number of feet in length of pipe 4 inches diameter, which will produce the desired effect.

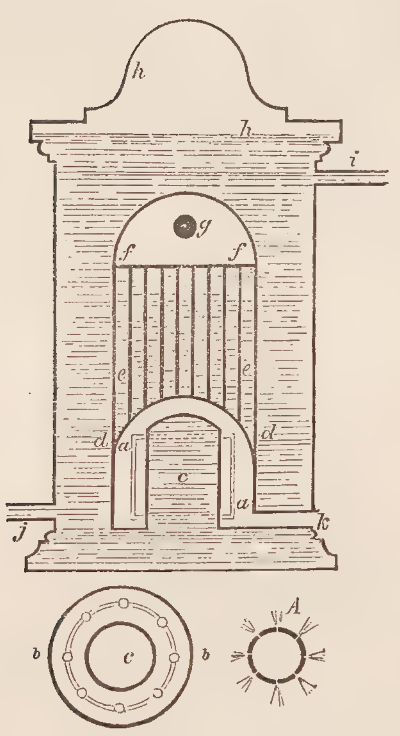
"When the pipes which are to be used are 3 inches diameter, then the number of feet of 4-inch pipe, obtained by this rule, must be multiplied by 1·33, which will give the length of 3-inch pipe; or, to obtain the quantity of 2-inch pipe, the length of pipe 4 inches diameter, obtained by the rule, must be multiplied by 2, the length required of 3-inch pipe being one-third more than 4-inch, and the length of 2-inch pipe being double that of the 4-inch when the temperatures are the same in all." (P. 116.)

53. *Gas*, as a means of heating masses of air, has been in use for some time; but against this use considerable prejudices obtain. Nor need we wonder at this, for in defiance of all the laws of health, the forms of apparatus by which it has been made available have been persistently constructed. The normal form or type of the gas stove as generally used, consists of an external cylinder of iron more or less ornamented in the interior of which a coil of gas tubing is placed. This is perforated at intervals with apertures, from which the gas escapes. When lighted, the heat raises the temperature of the case which encloses the coil, and thus warmth is obtained to the room in which the stove is placed. But something more than warmth is unfortunately obtained also, for not only is no provision made to prevent the overheating of the case, but the products of combustion are allowed to pass off into the room, contaminating its atmosphere with noxious and disagreeable smells. The result of this most unscientific mode of heating by gas is undoubtedly the prevention of an introduction of a better class of apparatus; for once disappointed in any invention the public are chary of having anything to do with apparatus based upon it, however different in arrangement and more valuable it may be. But it is by no means a difficult matter to arrange an apparatus by which gas can be employed as the means of warming it, and of producing large and healthy masses of warm air. Let us glance at the means by which this desideratum can be effected.

54. The first essential is to have a pipe, or tube, to carry off the products of combustion to the open air as fast as they are generated in the interior of the stove. The second is to have arrangements by which to prevent the overheating of the air. When these two essentials are provided for, gas stoves will be as healthy as undoubtedly they are economical, easily controlled, and maintained in operation at little trouble.

55. The first essential, noted above, is so simple a matter to be obtained that no space need be taken up by its further consideration. The second is by no means so easy of attainment. The most obvious means to prevent the overheating of the air is to consume it in a stove somewhat similar to that in fig. 8, where the flame will be surrounded with fire-lump, as shown by the dotted lines, or within the interior of a stove on Gurney's plan, as illustrated in fig. 9. The best way to use gas is, in our opinion, however, to burn it in a water-stove. The section in fig. 10, Plate XXXIII., will give a very fair idea how this plan could be carried out. Fig. 19, which is a sketch of a gas hot-water stove designed by the author, will give a few hints on the subject. The chamber in which the gas is consumed is at *a a*; it is circular, and entirely surrounded

Fig. 19.



Gas Hot-water Stove.

by water. The gas-burners are formed by a series of tubes placed vertically, and punctured with holes all round, so that the tube is surrounded with jets of flame. The tubes are shown in plan at *b b*; the interior is not a hollow space, but in order to economise as much of the heat of the gas as possible a cylinder, filled with water, is placed at *c c*. *A* shows a section, full size, of one of the vertical gas tubes *b b*. The chamber is finished with a dome *d*, and tubes *e e* carry up the heated products of combustion to a domed chamber *f f*, from which they are carried off by chimney *g*. The tubes *e e*, and domes *d d*, *f f*, are all completely surrounded with water, space being left at the upper part of the stove for the same to expand in. An aperture should be placed in the top *h h* to admit of the steam passing off, but the heat should be so regulated as to keep the water below the boiling point. Where a supply of hot water is required to warm other places, a tube *i* will take off this—*j* being the return tube. The gas in the chamber *a a* is lighted through the door *k*. One great advantage possessed by gas is the facility with which its consumption can be regulated to almost any degree of nicety. This, in conjunction with its decided cheapness as a fuel, when properly consumed, will, in process of time, bring about, we venture to think, a very much more extended use of it than we have hitherto witnessed. As an aid to efficient ventilation its powers are great, and will also be hereafter more fully recognized than they are now. Of its utility in this latter department we shall have occasion to report at its proper place in that important department of sanitary science, to which we now beg to direct the attention of the reader.

VENTILATION.

56. Although not strictly within the scope of our paper, it will be useful to notice a few of the points connected with the theory of ventilation, and more especially the physiological necessity demanding a supply of fresh air to our dwellings. The blood, as it passes through the lungs, being drawn in by the act of inspiration, is exposed to the action of the atmosphere as follows:—When it enters the lungs from the right side of the heart it is in colour of a deep red; but as it passes through the finely-ramified divisions of the lungs it is exposed to the action of the atmosphere, which changes the colour of the blood from the dark deep to a bright red. Passing, then, from the venous, it goes on to the arterial system, being, after it is aerialized, so to speak, passed to the left side of the heart. From this it is forced through the whole series of arteries, gradually losing its bright red colour as it gathers impurities from the body, until, having its deep red restored, it is passed to the veins to be delivered to the right side of the heart, from whence it passes to the lungs to be aerialized as before. But as this process goes on in the system, a remarkable change takes place in the air, which is drawn into the lungs. When respired after coming in contact with the venous blood in the lungs it is no longer life-supporting; but the oxygen which was formerly in it is changed into carbonic acid gas. The respired air is thus noxious, and further, it is rendered still more unhealthy by the animal matter and effluviæ contained in the aqueous vapour which the respired air brings with it from the lungs. Generally all writers have contented themselves with noticing the carbonic acid gas contained in the breath which passes from the body as the principal—if not the only—cause of its unhealthiness; but Dr. Angus Smith of Manchester, a well-known sanitarian, has very pointedly drawn attention to the offensive animal matter contained in respired breath. So important are his remarks that we deem it right to give them here, suggestive, as they are, of points not yet hitherto sufficiently considered.

"That animals constantly give out a quantity of solid organic matter from the lungs may readily be proved by breathing through a tube into a bottle, when the liquid, or condensed breath, will be collected at the bottom of the bottle, or by breathing through a tube into water, when a solution of the same substance will be found in the water. This would scarcely require proof if we considered that breath has so frequently an organic smell; perhaps, rather, it has always an organic smell, and when it is bad the smell is often offensive, containing decomposing organic matter.

"If this condensed breath be put on a piece of platinum, or on a piece of white porcelain, and burnt, the charcoal which remains and the smell of organic matter will be conclusive. If it be allowed to stand a few days (a week is enough), it will then show itself more decidedly by becoming the abode of small animals. These are rather to be styled animalcules, and very small ones, certainly, unless a considerable quantity of the liquid be obtained; they may be seen by a good microscope. Animalcules are now generally believed to come from the atmosphere, and to deposit themselves on convenient feeding-places, that is, they only appear where there is food or material for their growth, and they prove, of course, the existence of that continuation of elements necessary for organic life. At the same time their presence is a proof of decomposing matter, as their production is one of the various ways in which organized structures may be broken up. Such a liquid must, of course, be an injurious substance, giving out constantly vapours of an unwholesome kind.

"I mentioned some time ago that I had got a quantity of organic matter from the window of a crowded room, and I have since frequently repeated the experiment. This matter condenses on the glass and walls in cold weather, and may be taken up by means of a pipetta. If allowed to stand some time it forms a thick, apparently glutinous, mass; but when this is examined by a microscope it is seen to be a closely-matted, confervoid growth, or, in other words, the organic matter is converted into confervaceæ, as it probably would have been converted into any kind of vegetation that happened to take root. Between the stalks of this confervaceæ are to be seen a number of greenish globules, constantly moving about various species of valvat, accompanied also by monads many times smaller; when this happens the scene is certainly lively and the sight beautiful; but before this occurs the odour of perspiration may be distinctly perceived, especially if the vessel containing the liquid be placed in boiling water.

"When this exhalation from animals is condensed on a cold body, it in course of time dries up and leaves a somewhat glutinous organic plaster. We often see a substance of this nature on the furniture of dirty houses, and in this case there is always a disagreeable smell perceptible. I have no doubt that this is a great cause of the necessity for constant cleaning, which experience has found, and made it to be a very general practice in England and elsewhere. In other words, it is a reason why that which is not cleaned becomes dirty—a question which I have often felt great difficulty in answering.

"Water is necessary to the spontaneous decomposition of animal matter, and it is probable that in a warm climate this coating of walls and furniture would not be so dangerous as with us, where everything is exposed to moisture a considerable part of the year. In a warmer climate it will probably be diffused into the atmosphere, and not be so much retained as it is by the moisture which dissolves it, or to which it attaches itself. It will probably be found that this substance is not poisonous if taken into the stomach; but it is known to be poisonous if breathed into the lungs, as we know crowded rooms are. The quantity is small that we do breathe, but at the same time we must remember that it is diffused in air, and has, therefore, a surface as extended as the volume of the air in all probability; and we know that a cubic inch of sulphuretted hydrogen will scent, at least, some hundred cubic feet of air."

57. The following is a summary of the results of Dr. Smith's investigations on this important point:—

> "First,—That the pollution of the air in crowded rooms is really owing to organic matter, not merely carbonic acid.
>
> "Second,—That this may be collected from the lungs or breath, and from crowded rooms indifferently.
>
> "Third,—That it is capable of decomposition, and becomes attached to bodies in an apartment, where it probably decomposes, especially when moisture assists it.
>
> "Fourth,—That this matter has a strong animal smell; first, of perspiration, and, when burnt, of compounds of protein, and that its power of supporting the life of animalcules proves it to contain the usual elements of organized life."

58. From what has just been given, the necessity—where health is considered—of getting rapidly rid of the air which has been *once* breathed will surely be apparent. We shall, therefore, without taking up further space on the physiological, proceed to the theoretical and practical department of our subject.

59. In paragraph 5 we explained the process of convection, by which a fluid, as water, becomes heated by coming in contact with a heated body, and how the process induces a continual current of ascending and descending fluid. What is observed in heating a mass of water happens also in the case of a mass of air. If we suppose a red-hot mass of metal to be suspended in mid-air, as *a* in fig. 20, the particles of air immediately in contact with it become heated, and ascend, as shown by the arrows *b b*; other particles, indicated by *c c*, flow in from the surrounding atmosphere to supply the place of *b b*; and these in time become heated by the mass, and in time ascend. A succession of particles become heated and ascend; and if we suppose these to cool, after a time they descend to take the place of others ascending, and so a continual current is kept up.

Fig. 20.

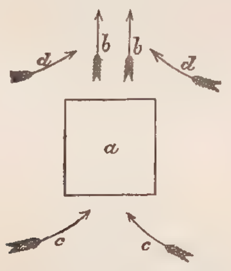


Diagram illustrating Ventilation.

60. The velocity of an upward current depends upon the difference between the temperature of the air composing it, and that of the body of air surrounding it. Where a quick current is required—or a draught, as it is termed—the usual method is to confine the heated air in a tube, or duct; this is called a flue or a ventiduct.

61. From what we have said it will be evident, on consideration, that an essential element in the establishment of a current of air is a continuous supply of air from below to supply that which is taken away from above. This is so like the statement of a truism that the reader may feel surprised at our giving it; but evident as the matter is, it is somewhat remarkable that it has been overlooked by many in their attempt to ventilate apartments. To such, the establishment of an opening for the leading off of the foul air of a room has been all that has been deemed necessary, to the complete exclusion of all means for supplying fresh air. That the two are absolutely essential, and must proceed *pari passu*—(by equal steps)—in the concoction of all plans for ventilating apartments, is plain enough. To illustrate it, however, we give the following diagram in fig. 21. Suppose a mass of burning fuel *a* to be placed at the bottom of a tall box *b b*; at first the current of air will be well established upwards, but after a time there will be little or none, and finally there will be two currents, both very languid, one going down to supply the mass of fuel, the other ascending, carrying up the products of combustion and heated air. If the tube or box *b b* is narrow, the chances are that the fire will go out from lack of air. If it is maintained, it will be by means of such a small current that it will show that it is deriving its supply by a very roundabout way. But let an aperture, as *c*, be opened up, and the current up the tube will be wonderfully accelerated, for the fuel *a* will now be able to draw its supply of air from the nearest possible point. It is thus an axiom in the art or science of ventilation that two classes of apertures are required to get rid of the foul air of a room—one to supply fresh air, the other to lead off the foul. "A moment's reflection," says an authority, "will satisfy the mere student as to the truth of the position, that unless a new portion of air be admitted into any apartment, the portion which is already there will not be expelled. It is necessarily impossible to have ventilation without a movement of air. An ingress and egress might certainly, under peculiar circumstances, be effected alternately by one and the same aperture, and satisfy all the essential wants of nature, as in the case of ordinary respiration, where the mouth and nostrils serve as a passage for air both in inspiration and respiration; but unless its action were sustained as powerful in proportion to the movement of air required, and as regular and effective in its operation, it would be vain to expect that it would meet the demands of ordinary ventilation."

Fig. 21.

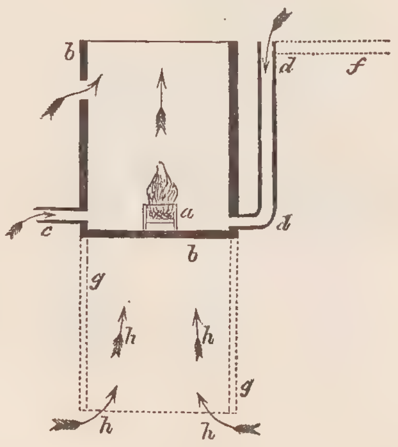


Diagram illustrating Ventilating Currents.

62. Two classes of apertures—one of egress for foul, and one for the ingress of fresh air—being required, the next point to consider is, which is their relative position? The natural course of heated air is upwards, therefore it seems also natural that the egress for foul air should be at the highest point of the building. But although the air sent out from the lungs is heated, it possesses—say those who advocate that the egress for the foul air should be at the lowest part of the building—other properties as well. "Air," say they, "when expelled from the lungs, being composed chiefly of carbonic acid gas, the specific gravity of which is more than one-half heavier than common air, must necessarily have a descending movement, and fall towards the ground, consequently it is easiest to withdraw it from the lowest part." Plausible as

this theory seems, and having, moreover, some degree of truth in it, it is only necessary to say that all experience tells us that breathed air and its carbonic acid gas have so much heat imparted to them on being expired that the tendency is upward. Moreover, ventilation has for its aim the withdrawal of the products of combustion of gas, lamps, or candles, from apartments, and these are, without doubt, highly heated. It is then, to put the matter mildly, a somewhat roundabout way of making foul air descend before it is allowed finally to ascend into the atmosphere, when its natural course is this ascension. (See the seventh and eighth sentences of par. 56.) The egress for foul air being, then, at the upper part of the building, the egress for fresh air is usually at the lower part. We say usually, for of late, systems of ventilation—to which allusion shall hereafter be made—have been introduced, by which the fresh-air ingress aperture is made at the upper part of the room, near to the aperture through which the foul air is withdrawn.

63. A current being established in an upward direction in any ventiduct, as *b b*, fig. 21, it may be made a power to create and sustain currents in other directions. Thus, in place of supplying the air through the horizontal pipe *c*, the pipe may be bent and extended upwards for a considerable distance, as *d d*, and air will be drawn down the pipe to supply the fuel burning at *a*; or this pipe may again be extended horizontally, as at *f*, so that air from a distance from the point *a* may be drawn by the current which it creates. Again, the current established up the ventiduct *b b*, through the agency of the fire at *a*, may be made the means of withdrawing the air from a space below the fire; by extending the ventiduct, as shown by the dotted lines *g g*, and placing the fire in a grating, the air will be drawn from the space *h*. These hypothetical cases are, in fact, illustrations of modes of ventilation which have been carried out with success, and to which hereafter we shall give special attention.

64. In reviewing the various plans which have been introduced from time to time to secure ventilation in buildings, we shall begin by noticing those of the most simple kind, in which natural means are alone trusted to, concluding with those of a more elaborate nature, in which artificial means and machinery are employed to establish and maintain the necessary currents.

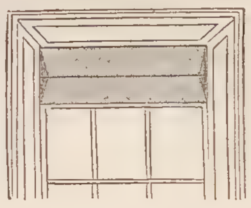
65. The oldest, and at the same time the most extensively-used means for supplying fresh and withdrawing foul air from a room, is the window. The opening of this to any required degree is so easily managed, and the relief obtained by it from a depressing atmosphere is so obvious, that we need not be surprised at its being so much relied upon, and maintained by many to be the "only true ventilator." While possessing advantages, the disadvantages it possesses are, however, numerous; not to detail these, we shall point out one only, namely, the impossibility of directing the current in any way desirable. However pleasant it may be to have fresh air wafted into a room which is unpleasantly close, it is not considered, nor is it in reality, safe to have the current blown directly upon the person. But this, with an open window, cannot be avoided, and the result is that in nine cases out of ten the window of a room is kept closed when everything makes it desirable that it should be open; and open it would be, in many such instances if the window could be so opened as to throw the current in some direction where it would not be felt by the parties in the room. French, or casement windows, possess this advantage, that one leaf can be opened at such an angle to throw in air to a certain part of the room; but this form of window possesses other disadvantages, which operate to prevent it being used to the extent it might be.

66. A window has, however, been recently patented by Messrs. West & Hubbell, Architects, of 25 Rupert Street, Haymarket, London, which possesses many features of novelty and utility, and amongst these is that by which ventilation can be secured. In fig. 1, Plate LXV., we give an elevation of the window as closed, and in fig. 2 an elevation in which the lower sashes are raised 6 inches and the top sash lowered the same distance. From the construction of the lower sashes, which swing after the manner of French, or casement windows, it is evident that these can be set at any angle so as to throw the current of air in any direction, and that either to the right, left, or straight forward. As they are capable also of being lifted, and the top sash of being lowered, a current of fresh air can be passing out of the top, and passing in at the lower aperture at the same time.

67. But however desirous some may be to open windows to obtain fresh air to their rooms, there are others, oddly enough, who have as great a horror of fresh as others have of foul air. This holds especially true of the lower classes, who most carefully close up all apertures through which, by any possibility, air can find its way into their apartments. This, together with the known disadvantages of open windows, operated in bringing out a variety of window ventilators. The most simple of these is the insertion of a pane of glass, with longitudinal perforations in it, these perforations being made at an angle to the plane of the glass, so that the air was projected up towards the ceiling, or down towards the floor, according to the position in which the pane of glass was fixed in the window. In Moore's window-ventilator strips of glass are placed in a frame, and swing on joints, so that the angle and the amount of opening can be regulated as desired by means of a cord. When this hangs loose, the slips of glass are tightly closed; and according to the position in which the cord is pulled and retained, so is the opening of the slips adjusted.

68. A form of window-ventilator which is now attracting considerable attention is that known as Cooke's patent. It possesses, at all events, the advantages of simplicity. The ventilators are constructed of wire-gauze, or zinc, perforated, and can be fitted to a window or door, or an outside wall, and which hinges or folds up when the window is closed. The foul air passes out through the apertures of the upper perforated plate, the fresh air entering at the lower. Fig. 22 gives an illustration of this ventilator as applied to a window. In all cases of window-ventilators, care should be taken to have the window-shutters of the room provided with perforations to admit of the ventilator in the window acting. If this is not attended to, when the shutters are closed in the evening, it is obvious that, no matter how perfect the ventilators in the window may be, they will be rendered useless.

Fig. 22



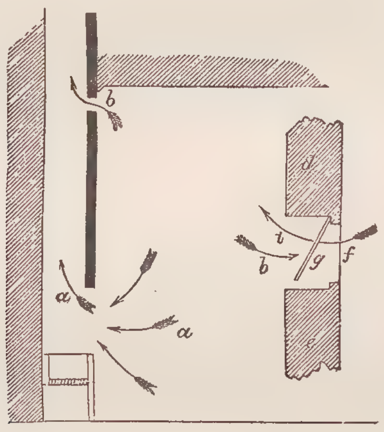
Cooke's Window Ventilator. Window down, Ventilator in Action.

69. If a rough rope be pulled with considerable velocity through a body of water, it will cause a movement of the water near it in the same direction in which the rope is pulled; and if the velocity is increased, it will lift out a certain portion. This is the principle on which the rope-pump works, If, in like manner, a thin stream of water be forced through a body of stagnant water, the forced stream will draw with it, so to speak, a portion of the water by which it is surrounded. A stream of air also moving upwards, as indicated by the arrows *b b* in fig. 20, will cause currents of air to be formed, tending in the same direction, as *d d*. Thus, if a current ot air *i* be passing up a tube *b b*, fig. 21; if an aperture be made in the

side of the tube, as at *e*, a current will be established through this, and will tend to withdraw the air from the outside of the tube *b b*. The movement thus originated doubtless owes its creation more to the vacuum which is formed on the one side, as by the upward current of air at *i*, fig. 21, and the air passing inward from *e* to take the place of the exhausted air—more from this cause, perhaps, than from that above alluded to. But although the friction of air passing through air is not much as compared to that of a rope passing through water, as above stated, the mobility of air is nevertheless so great that some portion of the current is due to the cause as above explained. Be this as it may, it is sufficient for us to know that currents are created in the manner as indicated by the diagram at *e i*, fig. 21.

70. Currents of air are thus well established in the flues of chimneys, so much so, that a perpetual current is passing from the room up the flue, in the manner shown at *a a* in fig. 23; and with the knowledge of this, the open fire-place is termed the best ventilator we have, it is undoubtedly a good form. But we may make the chimney a much more efficient ventilator if, by adopting the plan as suggested at *e* in fig. 21, we make an aperture at *b*, near the ceiling *c*, fig. 23; we then establish a current at the point where it is much, if not the most, required. This is the plan, indeed, recommended by Dr. Arnott, who thus remarks on it:—

Fig. 23.



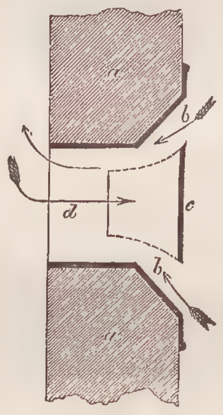
Chimney Ventilator.

> "Every chimney in a house is what is called a sucking or drawing air-pump of a certain force, and can easily be rendered a valuable ventilating pump. A chimney is a pump—first, by reason of the suction, or approach to a vacuum, made at the open top of any tube, across which the wind blows directly; and secondly, because the flue is usually occupied, even when there is no fire, by air somewhat warmer than the external air, and has, therefore, even in a calm day, what is called a chimney draught proportioned to the difference. In England, therefore, of old, when the chimney breast was always made higher than the heads of persons sitting or sleeping in rooms, a room with an open chimney was tolerably well ventilated in the lower part where the inmates breathed. The modern fashion, however, of very low grates and low chimney openings has changed the case completely, for such openings can draw air only from the bottom of the rooms where generally the coolest, the last entered, and therefore the purest air is found; while the hotter air of the breath, of lights, of warm food, and often of subterranean drains, &c., rises and stagnates near the ceiling, and gradually corrupts there. Such heated impure air no more tends downwards, again to escape or dive under the chimney-piece, than oil in an inverted bottle immersed in water will dive down through the water to escape by the bottle's mouth; and such a bottle, or other vessel, containing oil, and so placed in water with its mouth downwards, even if left in a running stream, would retain the oil for any length of time. If, however, an opening be made into a chimney-flue through the wall near the ceiling of the room, then will all the hot, impure air of the room as certainly pass away by that opening as oil from the inverted bottle would instantly all escape upwards through a small opening made near the elevated bottom of the bottle. A top window-sash, lowered a little, instead of serving, as many people believe it does, like such an opening into the chimney-flue, becomes generally, in obedience to the chimney draught, merely an inlet of cold air, which first falls as a cascade to the floor, and then glides towards the chimney, and gradually passes away by this, leaving the hotter, impure air of the room nearly untouched. For years past I have recommended the adoption of such ventilating chimney openings as above described, and I devised a balanced metallic valve to prevent, during the use of fires, the *escape of smoke to the room*.

71. The point referred to in the sentence which we have italicised in the above extract is one of importance. The valve, invented to obviate the objection to these chimney-openings, was a somewhat complicated apparatus; but the principle has been carried out in a simpler and cheaper form, as illustrated in fig. 23, where *d e* represents the wall of the flue in which an opening is made; in front of this a piece of perforated zinc *f* is nailed, and in the inside of this a flap of silk, *g*, is hinged at its upper edge. When a down draught, indicated by *b*, drives the smoke outwards towards the zinc plate *f*, it catches the flap *g*, and closing it tight against the zinc plate *f*, prevents all smoke from passing to the room. As soon as the down draught ceases, and the up current, indicated by *i*, commences, the flap *g* is opened as before, and the foul air flows through the apertures of the plate *f* and up the chimney.

72. A very ingenious form of chimney-ventilator has been introduced by Mr. William Brydon of Edinburgh, and which we illustrate in fig. 24. *a a* the wall of chimney-flue next the room; the aperture in this is cut of a conical form, so that the part *b b* is much wider than the part *d*. Immediately opposite the opening *d*, the part *c* is placed solid, while all round, at the parts *b*, holes are perforated as shown. Through these apertures the foul air is withdrawn from the room and passed up the chimney; while if a down draught takes place, it strikes against the solid part *c*, and finds no access to the room. We think an improvement would be made in this by having a hood, as shown by the dotted lines fixed to the inside part of the solid part *c*.

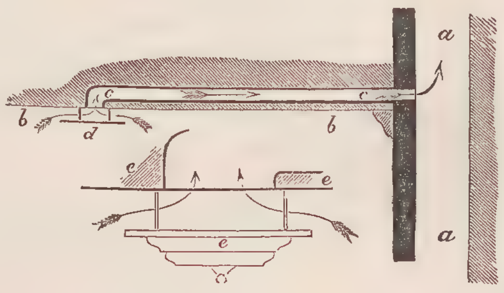
Fig. 24.



Brydon's Chimney Ventilator.

73. In place of withdrawing the foul air from the side of the room by the plans indicated in figs. 23 and 24, the chimney may be made available to withdraw it from the centre, in the manner indicated by the diagram in fig. 25, where *a* is the interior of the flue, *b b* the ceiling-line, *c c* a tube, or passage above the ceiling, leading to the flue *a*. A plate *d* is suspended below the aperture leading to the tube *c c*; this deflects the entering air, and draws it from the sides of the ceiling. This is shown at large at *e e e*.

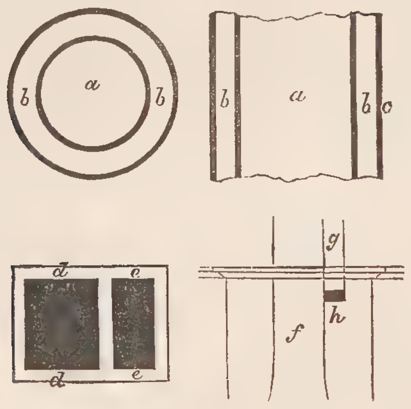
Fig. 25.



Ceiling Ventilating Tube.

74. If we suppose a central flue, as *a*, fig. 26, surrounded with a larger tube *b b*, leaving a hollow space between them; if the internal flue contains heated air, as a chimney, it will raise the temperature of the air in the channel *b b*, so that if an aperture *c* opens into this, a current through it will be established. This principle is now largely adopted, and is sometimes carried out by building alongside of the chimney-flue *d*, in fig. 26, a smaller flue *e*, which acts as the ventilating-flue. The lines *f* show in the front elevation the chimney-flue, *g* the ventilating-flue, the opening to which is at *h*, a little below the ceiling.

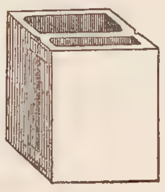
Fig. 26.



Ventilating Chimney Tubes.

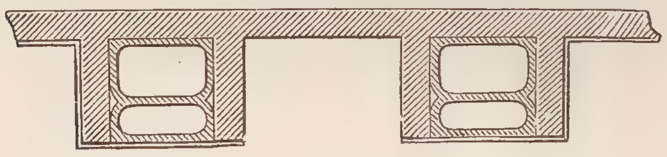
75. These combined smoke and air flues are now manufactured in one piece of pottery. The form patented by Mr. Walker of Manchester is illustrated in fig. 27, which is one length. Fig. 28 is a horizontal section of a chimney breast containing two of the tubes, taken at the level of an upper room fire-place. Fig. 29 is a horizontal section, taken above the ridge of a chimney-stack, consisting of six of these double tubes.

Fig. 27.



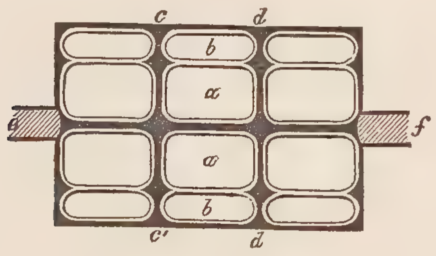
Walker's Chimney Ventilating Tube.

Fig. 28.



Stack of Walker's Ventilating Chimney Tubes.

Fig. 29.

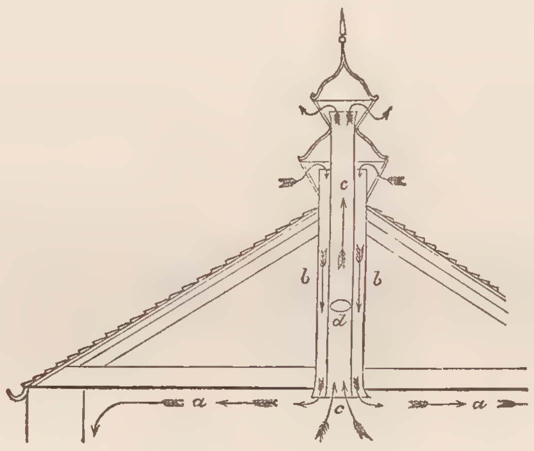


Stack of Walker's Ventilating Chimney Tubes.

76. These plans, described in figs. 21 to 29, with the exception of Cooke's patented system in fig. 22, have reference to the withdrawal of foul air, but do not provide for the supply of fresh air to the apartments in which they are placed. This may be provided by the window-ventilators already described, or a Sheringham's ventilator may be fixed in the external wall. This is placed near the ceiling, and opens outwards, and by means of a cord which passes into the room, can be adjusted at any desired degree of opening. Report speaks favourably of the performance of this fresh-air supplier. Mr. Davies has invented a Combined Ventilator for withdrawing foul and supplying fresh air to rooms. The following is a brief statement of its arrangement. Two tubes are provided in the apparatus; these both communicate with the external air and the room. The lower tube passes horizontally through the wall of the room; the upper tube is inclined, the lower end of the incline being towards the room. Both ends of each tube are covered with wire-gauze. In each tube a series of valves are situated, the valves in the lower tube opening towards the interior of the room, and those in the upper tube towards the external air. The fresh air may also be supplied to the room by means of tubes leading from the external air to the spaces behind the skirting, which should be perforated to allow of the air to pass into the room. But of all the methods proposed to supply fresh air to rooms, none surpasses, we think, both for efficiency and economy, that plan in which the air is passed behind the fire-place into spaces there arranged. The air is supplied, not only in ample volume, but it is warmed in winter —a most essential desideratum, which no other plan of giving fresh air gives. We have, in the first part of this Essay, while treating of Warming, illustrated and described modifications of this plan, as in figs. 5 and 6, and in fig. 1, Plate XXXIII.

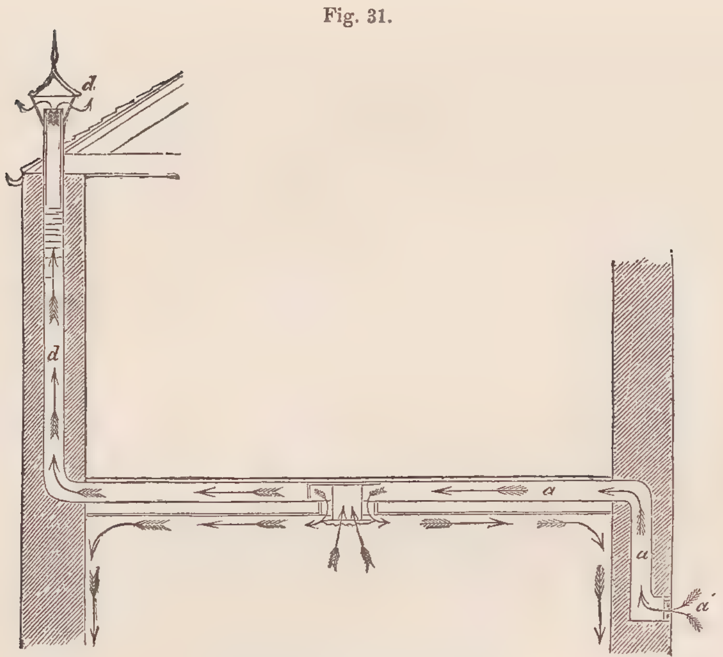
77. We have, in par. 62, alluded to those systems of ventilation recently introduced, in which the aperture for admitting fresh air, and that for taking off the foul, are placed at the highest part of the ceiling, and both close together. Various arrangements have been introduced to carry out this principle, one of which we illustrate in fig. 30, and which is the patented invention of Mr. J. M'Kinnell, 33 Stockwell Street, Glasgow. Let *a a* represent the ceiling of the upper storey of a house, with the ventilating apparatus carried through the roof. A tube of zinc, *b b*, or other suitable material, is fixed in the ceiling of the apartment. Inside this tube, and concentric with it, is placed a smaller tube *c*. These tubes communicate with the external atmosphere at different levels, the vitiated air rising up the central tube and passing off at the higher level; while the fresh air enters the annular passage, between the inner and outer tubes, at the lower level, and descends into the apartment below, as indicated by the arrows. Both passages are defended from rain, soot, &c., by perforated zinc or wire gauze, and provided with suitable valvular mechanism for regulating the currents—that of the outer passage, in the form of a projecting flange, which deflects the downward current of fresh air, and spreads it out horizontally, so as to render its action imperceptible, while the ascending current is regulated by a simple throttle-valve *d*. The valves are acted upon by cords passed over pulleys, and taken to any convenient point." Fig. 31 shows the mode in which lower apartments are ventilated. The arrangements are similar, except

Fig. 30.



M'Kinnell's Ventilating System.

Fig. 31.



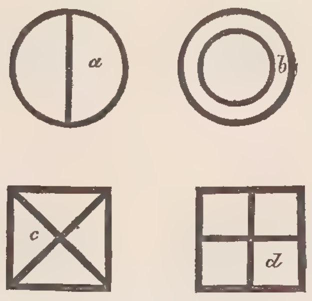
M'Kinnell's Ventilating System.

that the fresh air enters the annular space *horizontally* by *a a*, and the vitiated air is discharged by *d*, which is connected with the centre tube of the ventilator. The horizontal part of tubes *a* and *d* may embrace any portion or the whole of the space between two joists and the floor and ceiling. The vertical portions consist of flues in or outside the walls or partitions. In both cases the arrows readily indicate the direction of the ingoing and outgoing currents.

78. We have now to notice a plan in which the foul and fresh air ventiducts are at the same level, and both near the ceiling, but in which the arrangement of the ventiducts is on a totally different principle from that just illustrated. The following description of it from the "Building News," together with some remarks, may be useful:—

> "Although many schemes have been devised to accomplish ventilation, yet they have either been too complex and expensive, or have been contrived without reference to any well-defined and simple principle, which, once understood, would make their application easy. The want of a principle capable of reasonable explanation too often leads to disappointment, when a method, having succeeded in one building, has been applied to another of different construction, or placed in a different position.
>
> "It is true a principle has usually been followed, which is, that as air, when heated, rises, the openings for exit should be in the ceiling, and the openings for inlet of fresh air at the floor. This being only partially true, has led to much disappointment.
>
> "It is no doubt correct to say that air, as it is warmed, becomes lighter, and should be allowed to escape at the ceiling, but it is incorrect to say, also, that the fresh air should be admitted at the floor, the truth being, that all openings for ventilation should be as high as possible. When admitted at the floor the air must get warm ere it can rise, but when admitted at the ceiling, its own superior gravity causes it to descend, and thereby force out the foul hot air which has risen to the ceiling,
>
> "A ventilator, therefore, that supplies both an inlet and outlet at the ceiling is more powerful than one of equal dimensions, the one part of which is on the floor line, and the other at the ceiling. Besides this great advantage there are others, such as the better quality of air obtained from a distance from the ground, the greater distance of the point of entrance from the part of the room in which the persons occupying it stands, thus avoiding draughts, and the facility thereby afforded for diffusion before reaching the floor.
>
> "This first point being ascertained, it becomes a question by what arrangement can an exchange of air be accomplished. Of late years a ventilator has been constructed on what was, by scientific men who did not take the trouble thoroughly to examine the matter, thought to be a "natural law" proceeding on some occult principle. The ventilators so constructed either consisted of a cylinder divided by a mid-feather, as *a*, fig. 32,* or of two cylinders, one inside of the other, *b*, fig. 32,† and it was believed that by the operation of this "natural law" the one would always have an upcast and the other a downward current. The frequent variations in practice from the operations of this supposed law have puzzled observers, but we believe the explanation of these variations given by Mr. Muir of Manchester, will account for them, while the ventilator constructed by him fulfils all the required conditions. Mr. Muir's experiments satisfied him that the most potent of natural laws to employ in ventilation is the motion of the atmosphere, and to secure openings on all points of the compass, so that the air may always be entering by the opening to windward, while the hot and impure air escapes to leeward. These experiments prove to demonstration that the principle described by Tomlinson and other writers on ventilation is dependent entirely on the direction of the wind, a discovery that will displease all who admire the marvellous and mysterious, but will be hailed by all practical men as consistent with common sense. . . . .

Fig. 32.



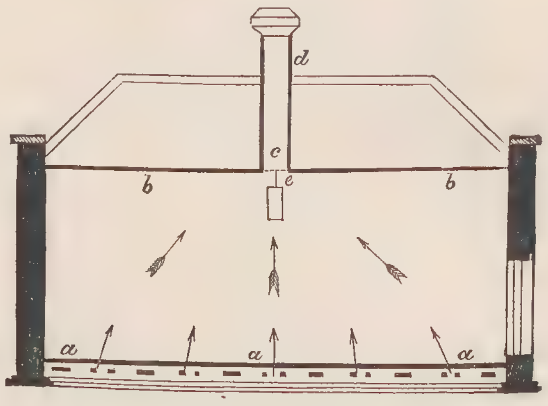
Diaphragm Ventilators.

> "In practice Mr. Muir divides his ventilators into four equal parts, either at an angle of 45°, as at *c*, fig. 32, or at right angles, as at *d*, fig 32. The superiority of this arrangement over either the single mid-feather or the double cylinder is at once apparent. In the single mid-feathered cylinder the double action is entirely frustrated when the air moves in a line with the mid-feather. And in the double cylinder the air frequently descends by both cylinders, and the opening by which the impure air is supposed to escape is at all times surrounded by the hollow column of air entering by the annular opening formed by the outer tube.
>
> "We have treated this subject as if it were one still to be tested by experience; but in addition to theoretical accuracy, we have practical experience to confirm it.
>
> "The four-points ventilators have been extensively used, and will undoubtedly give satisfaction whenever adopted; for supposing there be, as some still maintain is the fact, an occult natural law, by which a divided cylinder has an upcast and downcast current of air, it is clear that this law is frequently interfered with by external atmospheric currents, which the admirable and simple arrangement of Mr. Muir has the effect of neutralizing."

79. So far as we have gone, our illustrations of ventilating arrangements are applicable chiefly to the maintenance of a healthy atmosphere in private apartments. The class of public buildings is one, however, from its importance, which requires to be specially attended to in the matter of ventilation. Space does not permit of our giving here very detailed descriptions of modes of ventilating public buildings, but one or two illustrations, taken in conjunction with the remarks we have already given in previous paragraphs, serve to explain the general principles to be followed out in such cases.

80. Let fig. 33 represent the section of a school which is required to be ventilated. Let *a a* represent the floor, beneath which is placed a series of hot-water pipes, represented in the

Fig. 33



Natural Ventilation.

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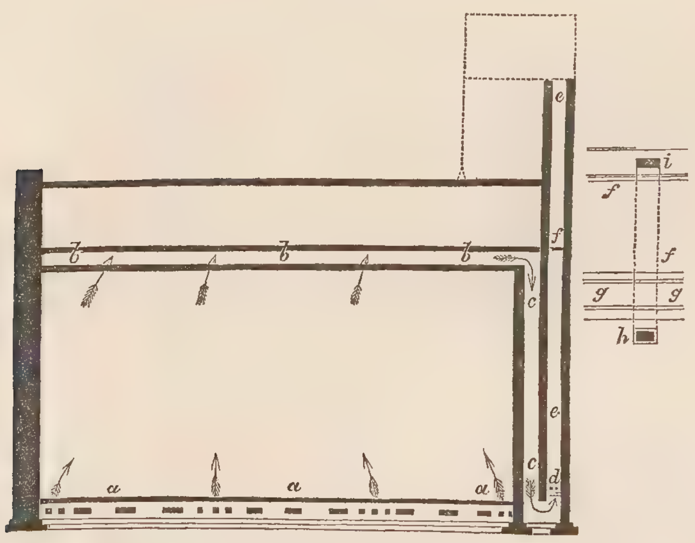
* This is the system patented by Mr. Watson of Leeds, and which has been very widely introduced.—Ed. W. D.

† M'Kinnell's plan, described above, in par. 77.

drawing by the dots; air is admitted from the external atmosphere through openings represented by the oblong spaces, and as it is warmed by coming in contact with the pipes, it rises up through grating placed at intervals in the flooring. The heated air finds its way to the ceiling *b b*, and up the ventiduct, or tube, *c*, which passes through the space between the ceiling and the roof, and is finished with a cap, or cowl, at *d*. By hanging a lamp *e*, or placing a gas jet in the interior of the tube *c*, a much more defined current will be obtained. This plan of ventilating has been carried out with marked success.

81. Fig. 34 illustrates the arrangements for ventilating a church. In this the heating pipes and the fresh-air ventiducts are beneath the flooring *a a a*; in the space between the ceiling and roof a horizontal chamber *b b* is made with openings in the ceiling leading to the interior; the foul air, passing through these, is drawn along the ventiduct *b b*, down the passage *c c*, by the force of the current created by the fire, or small furnace, *d*, placed at the bottom of the shaft *e e*, up which the air from the ventiduct *b b*, and the products of combustion are finally passed. In place of having a fireplace at the lower part *d*, thus necessitating the downcast shaft *c c*, a congeries of gas tubes with jets may be placed at the point *f*. Where this plan of maintaining the current by the use of gas has been tried, we may state that it has always given satisfaction. "By simply turning the cock," says an authority who has had practical experience in carrying out this system, "in the gas-pipe which supplies the jet, the rarefaction in the shaft, and consequently the velocity and quantity of the air passed through the church, may be controlled with tolerable accuracy, and instantly proportioned to any greater or smaller number of persons assembled. The cost of piping and cock for bringing the gas to the jets has been found to be but trifling; and as they need only be lighted during the time the church is occupied for worship, which is seldom of longer duration than two hours and a half, the consumption of gas is not very great, and amply compensated by the beneficial result obtained." The rapidity with which the ventilating currents can be produced by this "gas draught" system, the ease with which they can be regulated, and the facilities it offers for keeping them up *only* when required, with no previous preparation, all render it one which should be adopted whenever practicable. In the illustration in fig. 34 no gallery is shown; where there is one, the part under the galleries will have to be ventilated by having air-ducts let into the wall leading to the ventiduct *b b*. Thus, let *g g*, fig. 34, be part of the gallery; in the back wall the ventiduct is made, with an aperture leading to its interior, made a little below the ceiling of the gallery, as at *h*; a similar aperture, as at *i*, allows the air to gain access to the horizontal ventiduct *b b*. Means should be taken to regulate the admission of the fresh air and the exit of the foul by properly adjusted valves, indicated in part by the dotted lines.

Fig. 34.



Fire-draught Ventilation of Church.

82. Where the church to be ventilated is provided with a spire, or turret, as in fig. 34, this affords in itself an admirable ventilating shaft; but there are numerous meeting-houses in which there is no provision of this nature, so that the ventilating arrangements must take special form for such cases. We cannot do better than here give the remarks on this subject of Mr. Walker—(see Useful Hints on Ventilation)—who, from his wide practical experience in warming and ventilating churches and chapels, is fully entitled to be considered as an authority:—

> "The means most proper to be adopted for the plentiful supply of fresh air in the low-roofed, galleried, and crowded meeting-house, will be found to consist in abundance of fresh-air openings all round under the windows, communicating by brick flues with the lower part of the spaces under the aisles and seats in which the hot-water pipes that are to warm the air should be fixed. Fresh-air flues should be constructed between all the piers of the windows, running as high as the gallery, to supply it with fresh warmed air. A vitiated air-flue should also commence in each pier under the gallery (in order to give free egress to that which would otherwise be intercepted and detained under the gallery), and pass up into a horizontal trunk, running over the roof, along each side, into the foot of the upright shaft below the gas jets, as before explained. Openings should also be left in the roof, communicating with these horizontal trunks, to carry off the bad and heated air over the galleries. Hot-water pipes should be conveyed along the side walls under the floor, so as to warm the air that passes up with the piers into the gallery.
>
> "The leading points to be observed in such a case are delineated in the lower part of fig. 34, below the line *a a*. A much better provision should be made for supplying fresh air to such a house for worship, or other galleried building, than in one which has no gallery, and which possesses the advantage of an open roof; and those who would object to the copious measures here recommended as unnecessary, should well consider the following facts and calculations:—A chapel, or meeting-house, with large galleries nearly all round, capable of accommodating on special occasions 2,000 persons, is frequently made about 75 feet square and 25 feet average height, giving a total cubic content of rather more than 140,000 feet. Now, the authorities, from Tredgold to Reid, who have written on the subject of the quantity of fresh air required per minute by each individual to replace that which such individual has rendered unfit for respiration, vary in their conclusions from 3½ to 10 cubic feet; and if 7 cubic feet be assumed to be the proper quantity, an allowance near the average of their scientific opinions will be given. The total quantity required, therefore, on this low standard in such a building to maintain its atmosphere in a state of purity when filled, will be (2,000 × 7 =) 14,000 cubic fect every minute, and a like quantity of vitiated air must be carried off in the same time. The atmosphere of the building will therefore require to be completely changed or renewed (140,000 ÷ 14,000 = 10) *once in every ten minutes*. Let it now be supposed that the unusual provision of 16 openings has been made all round the building for fresh air, each opening measuring 18 inches by 6 inches. Deducting one-third of the area for impediment caused by gratings will allow to each opening a clear area of half a superficial foot, and the aggregate area of all the openings will be 8 feet. Now, to supply the required quantity of air (14,000 cubic feet) in the given time (one minute) through those openings, the air must pass through them all at the velocity of (14,000 ÷ 8 =) 1,750 feet per minute, or more than 20 miles per hour, which it will not do, especially on a calm day in hot weather—*when ventilation is most needed*—without the aid of some powerful stimulus; and if such artificial impulse be wanting, these openings will, under the circumstances, be quite insufficient to prevent the rapid deterioration of the atmosphere within, and ought, therefore, to be considerably enlarged. The bad effects of the usual way of obtaining a partial supply of air in such a case by opening the windows have been already commented on.
>
> "Take another example from a large Gothic church, with galleries, and lofty side aisles and nave, in the neighbourhood where this is written, measuring 80 feet by 65 feet, with a roof approaching to flatness, about 30 feet in average height. This church has often contained 1,800 persons, its cubic contents being 156,000 feet, and the require-

> ment of air, allowing, as before, 7 feet per minute to each person (1,800 × 7 =) 12,600 feet. The time in which the whole atmosphere of this church would, when containing its full complement of persons, require to be changed, is (156,000 ÷ 12,600 =) 12½ minutes, and large openings will obviously be required to pass the quantity in the time.
>
> "These figures will suffice to show the necessity for a very much larger provision for ventilation than has been customary in buildings containing galleries, in which the cubic contents bear a small proportion to the numbers assembled."

83. The methods of ventilating buildings, whether public or private, which up to this point we have explained, all come under the denomination of "natural" or "spontaneous" ventilation. Natural ventilation has been defined as "the maintenance of currents in the air of apartments by a process similar to that by which movements in the external air are created and upheld," and is very clearly and fully explained by Dr. Reid, and contrasted with *forced*, or *mechanical* ventilation (about to be treated of) as follows:—

> "For all ordinary purposes the natural method of ventilation will be found most eligible—that is, a process by which movements are induced or sustained in the air in the same manner as wind is produced in the external atmosphere, these movements being increased, when necessary, by the action of heat, and by the erection of a shaft, or chimney, that the heat may acquire additional force.
>
> "It is much questioned by various individuals whether a former or some other mechanical power is not more efficient and economical; but this question is a little more complicated than is generally represented, and the following observations are given with the view of illustrating the more prominent circumstances that bear upon it.
>
> "As air constitutes, in one respect, a balance infinitely more delicate than any that man can make, and as the most trifling increase or diminution in the density of any portion of air leads it to press more or less heavily than before on that which is immediately in contact with it, circumstances, almost too inappreciable at first to be considered worthy of notice, can nevertheless so alter its specific gravity that it immediately begins to press more heavily than before on that which surrounds it, or to give way before the pressure to which it may still be subjected if its density be diminished. But, though many popular misapprehensions are still entertained on this subject, it is universally acknowledged by all who have experimentally examined it, that the specific gravity of air, vitiated by respiration or combustion—the two great processes that deteriorate air in ordinary buildings—is, under ordinary circumstances, less than that of common air; it gives way accordingly, and is pressed upwards by the denser and purer air. Let us imagine, then, an apartment occupied (not inconveniently crowded) by a number of persons standing on a porous floor, and the roof off at ordinary temperatures, the air, vitiated there by the human frame, requires no mechanical power to remove it. The superincumbent pressure is diminished by the expansion induced in the air as it is heated, but the external atmosphere is permitted to have free access, below as well as above, to the porous floor. Its power, therefore, preponderates, and an upward movement is the necessary consequence, which is accompanied by the introduction of fresh air, and the removal of that air which is vitiated. Here, then, is a species of natural ventilation. All that is essential is merely this, that the natural movements induced by the heat of the body shall not be stopped by any barrier which may be opposed to them. An open roof and ceiling, however, is, in the greater of climates, inadmissible. Protection is required from the weather, independent of other arrangements; the opening, accordingly, may be contracted. In proportion to the amount of contraction, the temperature of the air and the numbers on a given space, it now becomes necessary to increase the velocity of the discharge from the apartment referred to.
>
> "To effect this, if a shaft, or chimney, be extended from any opening in or near the ceiling, the column of warm air which soon fills it increases its power, and unless an extreme number of individuals be crowded in the apartment, the shaft is sufficient for all ordinary purposes. It acts at all times when the density of the air within is less than the density of the air without; and when this is not the case, its power can still be developed by kindling a lamp or fire, or merely by increasing the temperature of the apartment for which it is supplied, as any of these causes produces the necessary diminution of density or rarefaction within, on which its force depends. If, however, it be proposed to use a mechanical power for the same purpose, machinery in the first place, more or less simple, must be prepared. Power must be applied to the machinery by manual labour, by water, by steam-engines, by a weight wound up from time to time, or in some other way; and however small the power actually required at any particular moment may be, it is more liable to accident, and more skill is required to maintain it in action. A chimney, therefore, from its extreme simplicity, and from the comparatively trifling attendance which it requires, is always preferable in numerous situations, while it involves no severe and long-continued manual labour, such as is apt to be neglected. Further, when properly finished at the top the wind acts as a power, and without any fire often determines the ascent of air."

84. There are occasions, however, as in very large public buildings, and in special structures, as theatres and factories where forced or mechanical ventilation can be more efficiently, if not more economically, carried out than natural ventilation on any of the plans we have described under that class. For what may be said in favour of mechanical ventilation, as applied to such buildings, we direct the attention of the reader to the following opinion of an authority:—

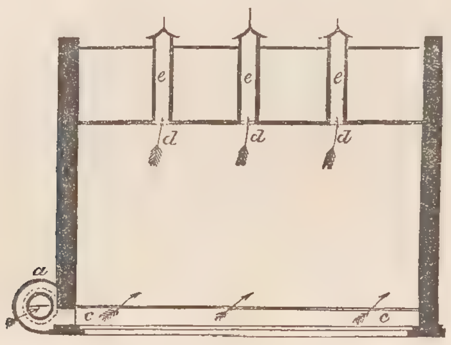
> "The method of ventilation by power is unquestionably the best that can be adopted, wherever there exists an engine for other purposes, or where the amount of ventilating duty to be performed is sufficient to justify the employment of a small one for that express purpose. Its effects are sure and infallible; any amount of air may be driven by it with certainty in any desired direction, and warmed, when the weather requires it, to any degree requisite for human comfort. The moderate cost at which steam-engines can now be supplied is a material consideration in favour of ventilating by power. In some recent cases a very simple form of direct acting-engine has been applied to this special object with success and advantage. Apparatus have also been invented, not only for simplifying the prime mover, but also for diminishing the attendance usually required by warming and ventilating contrivances, so that the means to be adopted are now so devoid of complexity, and the trouble of using them so much diminished, that it is hoped that ventilation by power will become much more generally used than has hitherto been thought of, even in buildings where steam-engines are not required for other purposes, the certainty of its action being such, and its effects so completely and instantaneously controllable, as to entitle it to a decided preference wherever it can be applied. The reasons for this preference will have the greater weight when we consider that owing to the difficulties which will sometimes unavoidably oppose themselves to the construction in buildings of flues and air-channels of size sufficient to convey the requisite quantities of air for crowded assemblies, they must occasionally be of a size which will prove to be too small for the purpose, unless their activity be increased, and the velocity of the air passed through them be accelerated by the impulse of some mechanical propeller, of power adequate to overcome the greater resistance caused by such velocity.
>
> "To no class of buildings will this remark apply with greater force than theatres, assembly and ball rooms, and lecture-rooms, where very great numbers of persons are frequently packed together, tier over tier, in the smallest possible space, their number at the same time being subject to great and sudden increase and diminution, and demanding, therefore, highly controllable ventilating agencies, so as to be quickly adapted, *without change of temperature*, to the greater or less number suddenly present at any given time. In theatres particularly these practical difficulties have been experienced by the writer to be rendered much more formidable, from the extreme value of space not permitting a single seat to be *sacrificed* (?) to purity of atmosphere. The expenses of large theatres are so great, and the extravagant demands of the principal performers, or 'stars,' so serious, that in the provinces especially their appearances are only occasional; and it therefore becomes necessary, in order to make these comparatively rare occasions pay the current expenses of the whole year, that sitting or standing room should be provided in every space within view of the performance into which a human being can be crammed. This increases the necessity for ventilation at the same time that it diminishes the facilities for obtaining it; and as space cannot be spared for thickening walls, so as to run up air-flues within them, or otherwise for constructing the desired air-channels, they are of necessity small, few, and far between, and these deficiencies can alone be compensated by forcing air through them at a higher velocity than that which would be caused spontaneously by the elevated temperature of the house. Again, at the conclusion of a favourite perform-

ance, and before the commencement of the after-piece, the house is frequently, and almost entirely, deserted. Hence the advantage of using power in such buildings, as it furnishes the only means by which inadequate channels can be made to perform double duty on special occasions, or by which their activity can be instantly lowered on a sudden cessation of the requirement."

85. Where, then, mechanical ventilation is decided on as the best, it may be carried out by one of the two modes—the "plenum," or "vacuum."

86. The "plenum" mode consists in the *forcing* of air into the interior of a building by a mechanical contrivance, as a fanner, *a*, fig. 35, drawing its supply of air from the atmosphere at *b*. The air is forced along the chamber *c c*, made beneath the floor, and finds its way to the interior of the building through apertures, or gratings, made therein, and finally, through the apertures *d d d d* in the ceiling, and from thence to the ventilators *e e*, placed in the roof.

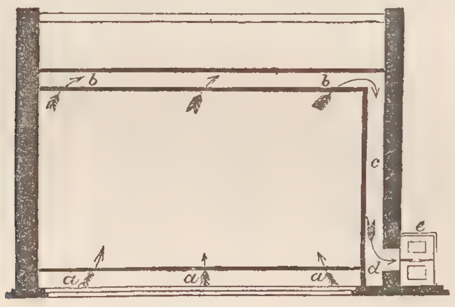
Fig. 35.



Plenum Ventilation.

87. The "vacuum" mode consists in giving a supply of fresh air to the interior of the building, as by the apertures *a a*, fig. 36, this passing through gratings in the floor. The foul air passes through ventiducts in the ceiling into a chamber *b b*, then drawn down the ventiduct *c* by the force of the current created by the revolution of the fanner *d*, and is finally passed into the atmosphere through *e*.

Fig. 36.

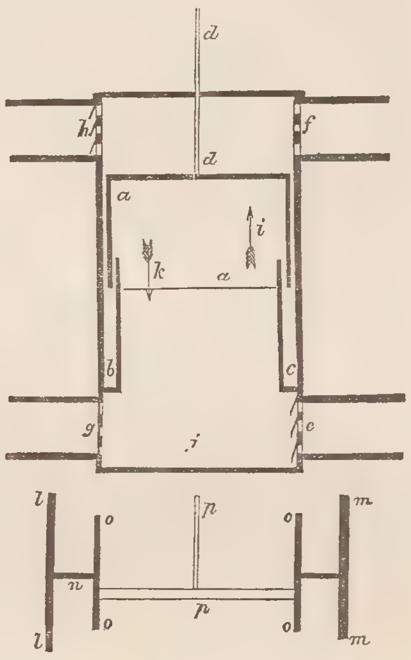


Vacuum Ventilation.

88. Each mode has its advocates, and it is difficult, in the absence of the particulars of arrangement of a building, to say which is the best to be adopted; generally speaking, however, it may be stated that the "plenum" mode, or propelling of air, is better than the "vacuum," or exhausting of air, as it has a tendency to decrease the density of air, and thus gives a little more oxygen in a given space. It is questionable, however, whether this advantage is really possessed by the propelling over the exhaustive method. Both are valuable, but there are circumstances which render one better adapted than another to ventilate a building; of these circumstances the architect and engineer will be the better judge. We are, however, more inclined to favour the propelling than the exhaustive method.

89. The mode of mechanical ventilation being decided on, the mode by which this is to be carried out is the point next to be considered. Mechanical ventilation is usually effected either by the "air-pump," the "screw," or the "fanner."

Fig 37.

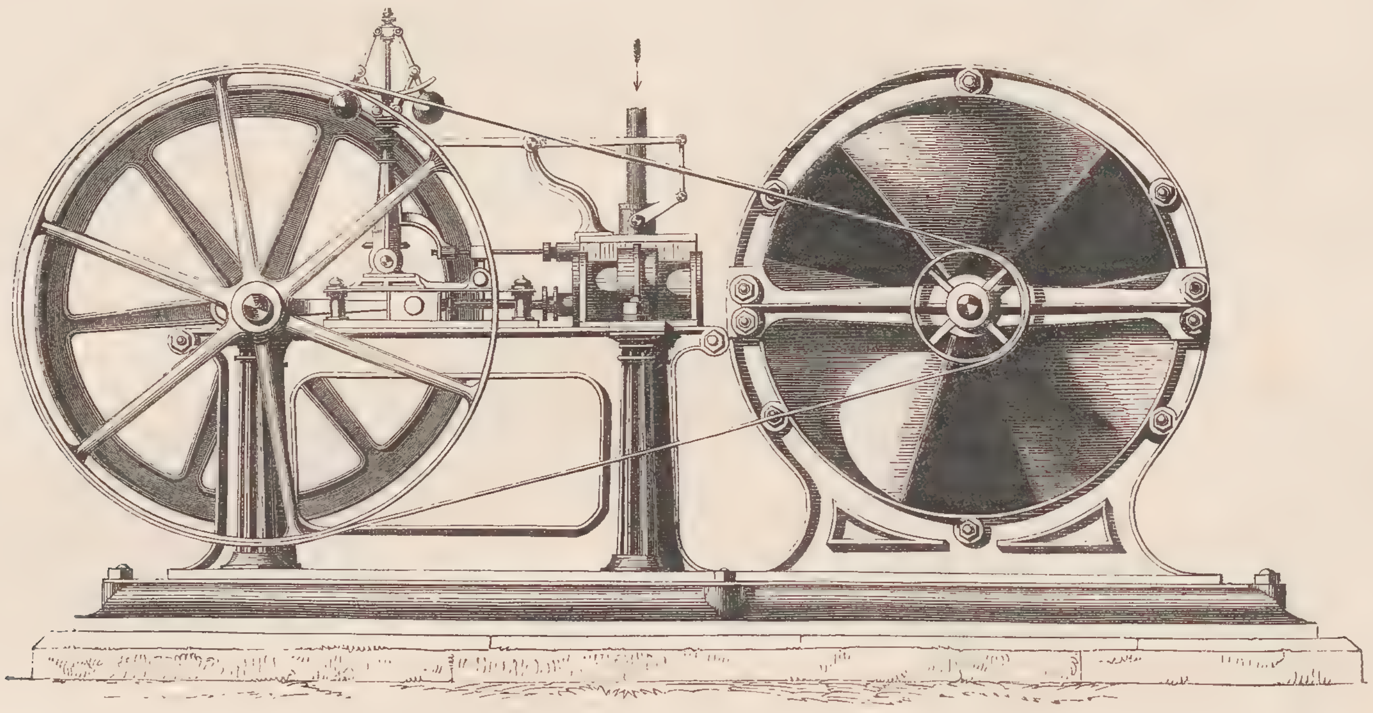


Arnott's Ventilating Pump.

90. The best form of "air-pump" is that introduced by Dr. Arnott, and which works on the gasometer principle, as illustrated in fig. 37. Let *a a* be a hollow vessel like a small gasometer, and working also like a gasometer in water-troughs *b c*. The chamber in which this is worked up and down by means of the piston-rod *d d* is closed at top and bottom, but has at one side two sets of valves, *e f*, one at the top and the other at the bottom; all these valves open *inwards*. On the opposite side of the chamber corresponding sets of valves, *g h*, are placed, but which open *outwards*. The valves *f e* communicate with passages leading to the open air, those at *g h* with passages leading to the interior of the building into which the air is to be pumped. On the piston, or hollow chamber *a a*, rising as in the direction of the arrow *i*, the valves *e* open and fill the lower part, *j*, of the chamber with air, the valves *g* closing; at the same time the air, which is in the upper chamber *d*, is forced out through the valves *h* into the building, the valves *f* closing. On the piston being depressed, as in the direction of the arrow *k*, the valves *f* open, filling the upper chamber *d* with air, *h* closing; at the same time the air is forced out of the lower chamber *j* through the valves *g* into the building, and the valves *e* close. The air-pump here shown can be made to ventilate a building either on the *plenum* or the *vacuum* principle. Thus, as above described, it acts on the plenum principle, but the foul air may be drawn from the building by passages leading to the valves *e f*, and expelled into the open air by the valves *g h*. With a piston 8 feet square, and with valves 8 feet long and 9 inches wide, and with a number of strokes equal to 50 per minute, the quantity of air can deliver 12,800 cubic feet of air per minute. A modification of the piston part of the pump is also shown in fig. 37, where *l l*, *m m*, are parts of the sides of the outer chambers in which the valves are fixed. This outer chamber is divided into two chambers, an upper and a lower, by mid-feathers *n n*; *o o* is the body of the pump in which the piston *p p* works. The valves are made of oiled silk, lined with green baize. The great advantage of this pump is, that large quantities of air can be delivered at a slow velocity rather than small quantities at a high velocity, which is the distinguishing feature of the fanner. This advantage is also possessed by the *screw* ventilator.

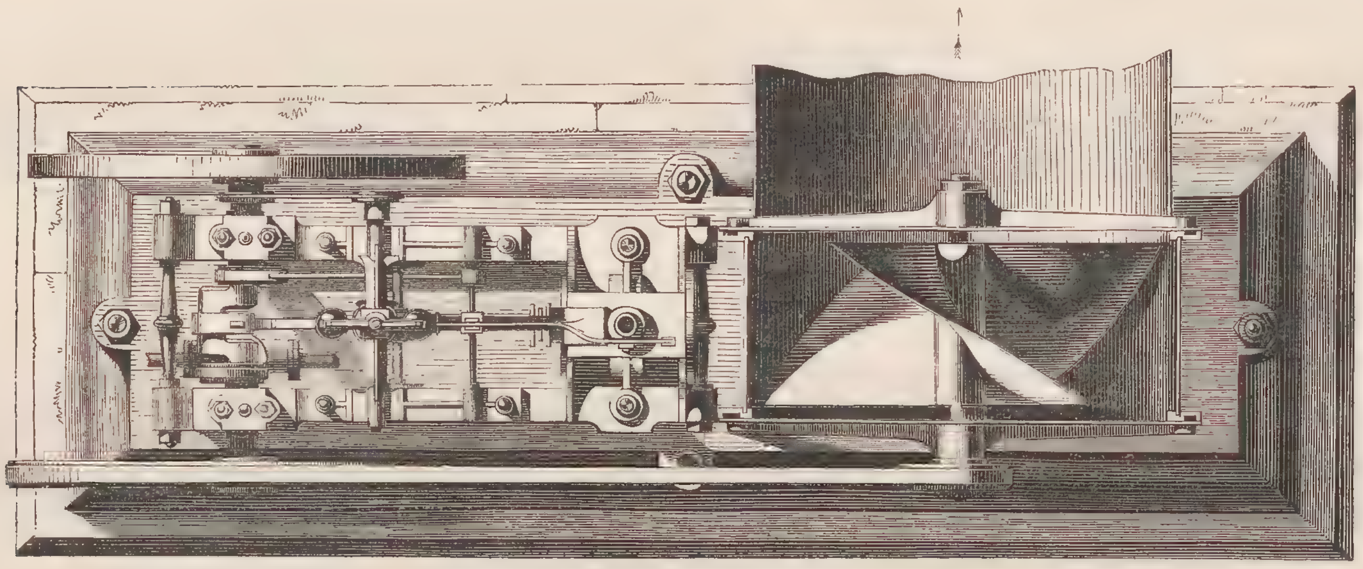
91. The form of screw is shown in plan and elevation in figs. 38 and 39, and end elevation, fig. 40, illustrating an exceedingly compact arrangement of steam-engine and ventilating apparatus (this owes its existence to the ingenuity of Mr. Walker of Manchester, whose contributions to warming and ventilating mechanism we have more than once in this Essay

Fig. 38.



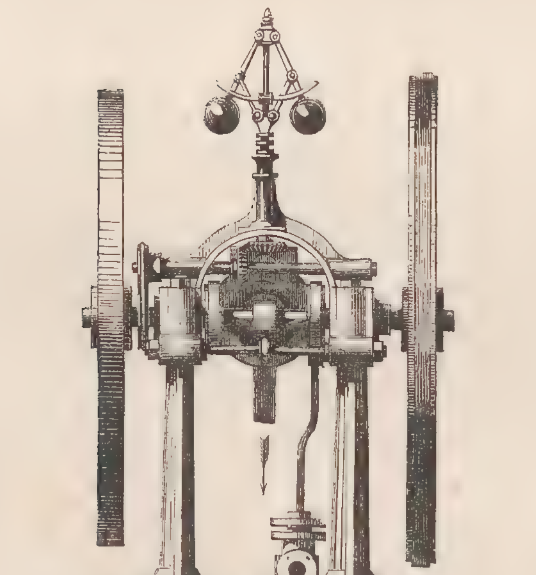
Walker's Steam Ventilating Screw (Side Elevation).

Fig. 39.



Walker's Steam Ventilating Screw (Plan).

Fig. 40.



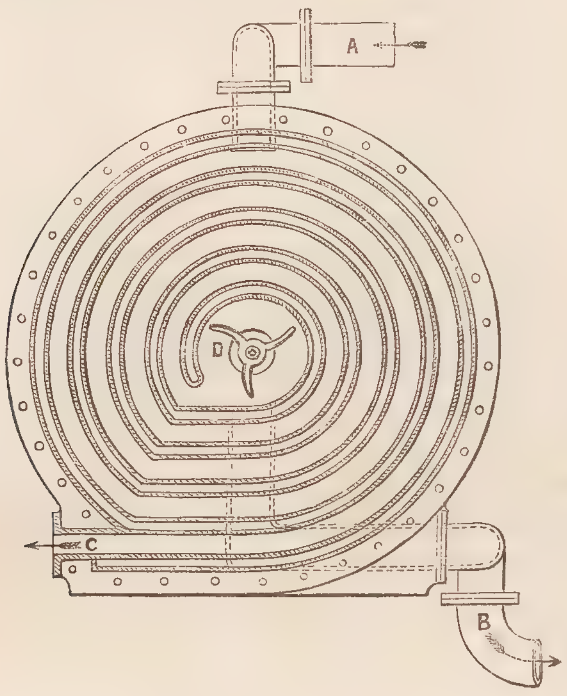
Walker's Steam Ventilating Screw (End Elevation).

had occasion to advert to). The action of the screw is somewhat different from that of the fanner; in the latter the air is drawn in at the centre and expelled at a point in the circumference; in the screw the action is more immediately propulsive, being simply drawn in at one side and expelled at the other. A screw, 4 feet in diameter, and having 500 revolutions per minute, delivers 5,000 cubic feet of air per minute.

92. The fanner illustrated in fig. 9, Plate XXXIII., as stated above, draws air in at the centre and discharges it at its circumference. It "produces its greatest effect when the extreme points of its leaves move through about 80 feet per second. The mean velocity of that portion of the vanes by which the air is discharged is about seven-eighths of the velocity of the extremities; but owing to the inertia of the air there will be a loss in the velocity of the issuing current, which will increase with the increased speed of the vanes, so that in general the current will be discharged with a velocity equal to about three-fourths of the velocity of the extremities. This velocity, measured in feet per second, multiplied by the area of the discharge-pipe in square feet, will give the number of cubic feet of air discharged per second. If the effective velocity of the vanes be 70 feet per second, and the sectional area of the discharge-tube be 3 square feet, then $70\times3=210$ cubic feet of air discharged per second, or 12,000 cubic feet per minute. As a cubic foot of air weighs 527 grains, there will be about 13 cubic feet of air to a pound, therefore $\frac{210\times60}{13}=969$ lbs. weight of air set in motion per minute, with a velocity of 70 feet per second. The height from which a heavy body must fall in order to acquire a velocity of 70 feet per second is 76·5 feet, which, multiplied by the number of pounds weight moved per minute, will give the power necessary to discharge this quantity of air at the stated velocity, and this product, divided by 33,000 (the number of pounds weight that one horse will raise one foot high per minute), will give the amount of steam power required. Therefore $\frac{76\cdot5\times969}{33,000}=2\cdot24$, or nearly $2\frac{1}{4}$ horse power, will be required to discharge the given quantity of air at the velocity stated." (For an able paper by Dr. Ure on the Fanner see the Philosophical Transactions.)

93. Perhaps the most ingenious method of combining the fan and a warming system in one, is that recently patented by Robert Davison, C.E., of 8 London Street, City, and illustrated in fig. 41. This plan is as simple as it is ingenious, and consists of a series of convolutions, which are of double plates, having a space between them, into which steam from the pipe A is passed; the fan D forces the air through the passage between the plates, and finally out at C, from which it can be led to the building. The condensed steam passes out at B. The temperature of the issuing air at C is regulated by the velocity given to the fan D. The cold air to be warmed is passed to the fan at the side openings as usual.

Fig. 41.



Davison's Patent Heating and Ventilating Fanners.

94. Another method of effecting mechanical ventilation is by the "steam jet," invented by Mr. G. Gurney. The steam is led—the pressure in the *boiler* being 50 lbs.—by a pipe to the bottom of the ventilating shaft, and is there provided with a series of conical mouth-pieces, or jets, so arranged that they shall be uniformly distributed over the sectional area of the shaft. The steam projected from these jets expands conically, and establishes a current upwards in the shaft. Dr. Young, many years ago, showed that air, when made to issue from a jet, diverges into the form of a cone. The quantity of air set in motion by the series of cones formed by the *steam* jets is very great, as much as 217 times the bulk of steam being raised. Dr. Faraday showed, in a series of experiments, the force with which the air surrounding was drawn in towards the cone. By surrounding the cones or jets with jackets, this force was considerably increased. The steam-jet system of ventilation has been applied with success to the ventilating of collieries, and was carried out by Sir Charles Barry at the House of Lords.

ARTIFICIAL LIGHTING.

95. Leaving out, as foreign to the purposes of our Essay, all notice of artificial lighting by means of candles and lamps, we proceed at once briefly to describe the method adopted in making gas in the ordinary manner. Those desirous of understanding the principal chemical features and the mechanical arrangements connected with gas making may consult, in the companion work to the present, entitled "Working Drawings and Designs in Mechanical Engineering and Machine Making," Essay Eighth, which treats of the "Mechanism of Gas Works, Breweries, and Mills."

96. In treating of the mechanical operation of gas making it will be advisable to consider first "*the coals used in gas making, and their carbonization or distillation;*" and second, "*the purification of the gas on its passage from the retorts.*"

97. *The Coals used in Gas Making, and their Carbonization or Distillation.*—The coals principally used in gas making are the *Parrot*, or *Cannel*, the *Newcastle*, *Derbyshire*, and *Welsh* coals. Into the details of the constituents of these coals we do not propose to enter, but to give examples of each, with the number of cubic feet of gas produced per ton:—

	Cubic ft.		Cubic ft.
Wigan Cannel, . . .	14,453	Newcastle coal, . . .	11,648
Scotch ditto, . . .	14,000	Derbyshire deep main, . .	9,400
Boghead ditto, . . .	15,000	Welsh coal, ...	10,000

The above table contains first-class examples of coal, but there are many samples which do not yield so much gas; indeed, gas coals of different quality yield from 6,000 to 15,000 cubic feet per ton, 10,000 cubic feet of gas per ton constituting the average products of a good gas coal.

98. *Carbonization, or distilling gas coal*, is effected by introducing it into iron or clay retorts, which are maintained at a red heat, and sealed air-tight; the gas and other products of distillation pass up the stand-pipe from the mouth of the retort into the hydraulic main, which is filled with water to a certain level; after the gas has passed into the main by the dip-pipe, which dips 2 or 3 inches into the water, it is effectually prevented from returning, owing to the height of the dip-pipe and its mouth being sealed with water. This is the first example of the advantage taken of the difference between the specific gravities of the two fluids—gas and water—whereby the latter prevents the escape of the former with a simplicity and certainty unequalled by any mechanical means. This principle, we will find as we proceed, is made use of in all the different contrivances in the purification and storing of gas.

99. In conducting the process of distillation, or carbonization of coal, the furnace must be kept at a regular temperature, so as to maintain the retort at a heat ranging from 1,650° to 1,830° Fahrenheit, or never lower than a cherry-red heat nor higher than bright cherry-red; too low a heat favours the formation of tar, which must be carefully avoided, and too high a heat, although it may produce more gas, is injurious to the retorts, and will in many cases bend and crack them. In charging the retort in a small gas-work, such as the one before us, from 150 to 200 lbs. of coal is broken up into small pieces, and is thrown into the retort with a scoop-shaped shovel; the lid (which previously has been luted with cement) is now lifted up to the mouth of the retort, and the cross-bar placed in the guides, and screwed up, pressing the lid upon the face of the retort, extinguishing the flame, and making the connection air-tight. This charge remains in the retort from six to eight hours, but six is quite sufficient; indeed, in some works the time for working off a charge is four hours, which no doubt secures a superior quality of gas, as, in allowing the charge to remain longer than four or six hours, the principal products of distillation are pure hydrogen, with a small quantity of light carburetted hydrogen, and which, if allowed to proceed and mingle with the products of the first part of the distillation, will materially impair its illuminating power, and cannot by any means be separated from it. Six hours having elapsed, the charge is ready to be drawn from the retort, but before drawing it, a spare lid, with which every retort is provided, is luted with cement, that is, equal parts of spent lime from the purifiers, and fire-clay made to the consistency of mortar, is spread to the depth of half-an-inch round the bearing surface of the lid. The screw of the cross-bar is slackened and the bar lifted out, the luting is then broken by a blow from a hammer, which also starts the lid, and a light is applied to consume the gas which is issuing from the retort before it is mixed with atmospheric air, as in such a case a most explosive compound would be

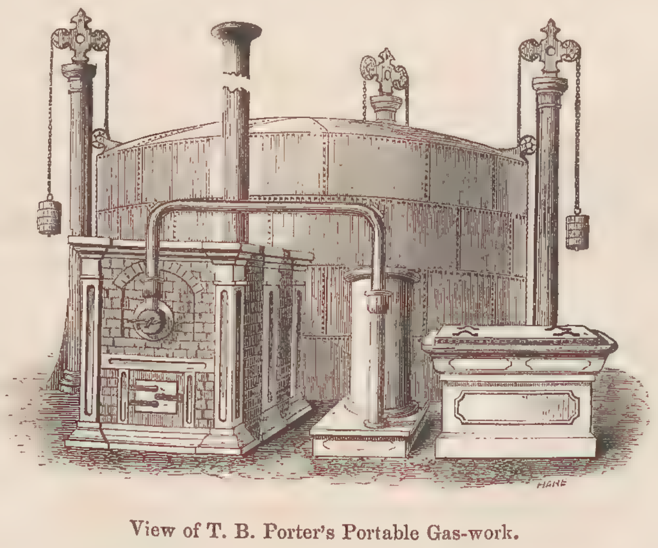
formed, and many accidents of the most serious kind occur. The lid may now be lifted off the retort and the coke raked out into an iron barrow placed immediately under the mouth of the retort; the barrow is then removed, the retort charged, and the lid secured as before. All this work may with ease be performed by one man when there are only three retorts in winter and one or two in summer. To prevent attendance at midnight either the retorts may be left empty and the dampers of the furnace partially closed, or a seven hours' charge placed at 11 o'clock at night and withdrawn at 6 o'clock in the morning. The coke made in the retorts is used to heat subsequent charges; in large gas-works one-third the coke produced is used to carbonize the coal, the remaining two-thirds being sold; but in such a small gas-work as the one before us, with one retort to each furnace, at least one-half of the coke will be used.

100. Proceeding now to the second part of this section, namely, *the purification of the gas on its passage from the retorts.* The first and minor operation of purification takes place in the hydraulic main, which consists of a long cylindrical vessel, closed at one end, but having at the other a pipe, which conducts the gas into the condensers, and also serves to convey the tar into the tank as it accumulates in the main; the "dip-pipe" is connected to the "stand-pipe" of the retorts, and is carried into the main, dipping below the tar or water to a certain depth, thus effectually sealing the mouth of the pipe and preventing the gas returning from the main into any of the retorts. Thus the gas in passing through the water suffers a slight reduction of temperature, causing a deposition of the heaviest portion of the tar, which is only gaseous at high temperatures. From the hydraulic main the gaseous products of distillation pass into the atmospheric condenser, which consists of a series of vertical pipes, connected at the top and inverted over an iron trough partially filled with water, and divided into a number of compartments by webs dipping into the water; the impure gas passes up and down a series of vertical pipes till it finally issues from the condenser by a horizontal pipe. The gas is now so much reduced in temperature as to have deposited all the tar which before formed one of the gaseous impurities. It has also got rid of a considerable portion of ammonia, owing to its great solubility in water; these impurities, which are retained in the condenser, trickle down the inside of the pipes, depositing themselves in the trough or tank at the bottom, and when they accumulate, overflow into the tar-tank which is situated at the end of the condenser underground. From the condenser the impure gas passes into the washer, or wash-vessel, the construction of which in many works differs, but in our supposed case consists of a square box, fitted with a series of webs, dividing the box at the bottom and open towards the top; other divisions are bolted in, having V-shaped webs running transversely, or across the box; the V webs dip 1½ inch into water, and are carried up to the top of the box, thus preventing the passage of the gas except by passing round the V webs under water; in this way the gas enters the one end of the box by a pipe passing under the first V web into the second compartment, ascending the division of that compartment, and passing out under the second V web, and so on to the end of the washer, passing over a partition and out by a pipe. The gas here is so thoroughly brought into contact with water, and likewise further reduced in temperature, that nearly the whole of the ammonia, which is soluble in water, is retained in the washer. A considerable quantity also of sulphuretted hydrogen saturates a portion of the soluble ammonia, or rather the ammoniacal liquor, converting it into sulphide of ammonia.

101. Thus we have the gas passing out of the washer nearly, if not quite, free from ammonia, and also partially freed from sulphuretted hydrogen. It is, however, absolutely necessary to subject the gas to further purification, owing to its still containing two most injurious impurities, namely, sulphuretted hydrogen and carbonic acid; this is effected by the action of lime, sometimes in a state of liquid and sometimes merely slaked, or hydrated; when used in the liquid state it is said to be more economical; it is, however, only used in large works, as the liquid lime requires continuous agitation, rendering motive power necessary. The latter being the system of purification used in small works, we shall endeavour to give an explanation of what are commonly called the "dry lime purifiers." These consist of two, three, and sometimes four rectangular boxes, open at the top, and having a double case running round, which is filled with water, thus forming a lute, and which is fitted with a malleable iron cover, the sides of which dip into the lute and render the purifier gas-tight. The inside is fitted with a series of trays or sieves, covered with a thickness of hydrated lime, that is, lime which has been slaked and slightly damped; the gas passes in at the bottom end of one purifier by a pipe through the grating, and up the series of trays on one side the division, separating the two sets of trays, and down the same number of trays on the other side of the division, passing out at the bottom of the opposite end by a pipe; from this it is directed into a second, and sometimes a third purifier, from which it is conducted into the gas-holder. The process of purification at this stage is supposed to be complete, and indeed, practically speaking, it is so, for the impure gas has been exposed to a series of layers of lime, for which both sulphuretted hydrogen and carbonic acid have a great affinity. Thus the gas has been freed from its two most offensive impurities as well as the remaining portion of cyanogen, which has also combined with the lime, thus forming sulphide, carbonate, and cyanate of lime, and occasionally a small portion of ammonia. The quantity of lime estimated to purify 10,000 cubic feet of gas is from one bushel of quicklime upwards, which, when slaked, gives twice the quantity, and will spread over a surface of 25 square feet, with a uniform depth of 2½ inches, which is the thickness found in practice to work best. Now, in the gas-work (see Plate XXVI.) before us there are two purifiers, measuring 4 feet 6 inches by 1 foot 11 inches, the area of which is 8·8 square feet, and in each purifier there are three layers of lime, divided into six trays, which will be 3×8·8= 26·4 square feet of lime in each purifier, and supposing the production of gas to be 12,000 feet every 24 hours, then each purifier will require to be renewed with a charge of fresh lime every 48 hours.

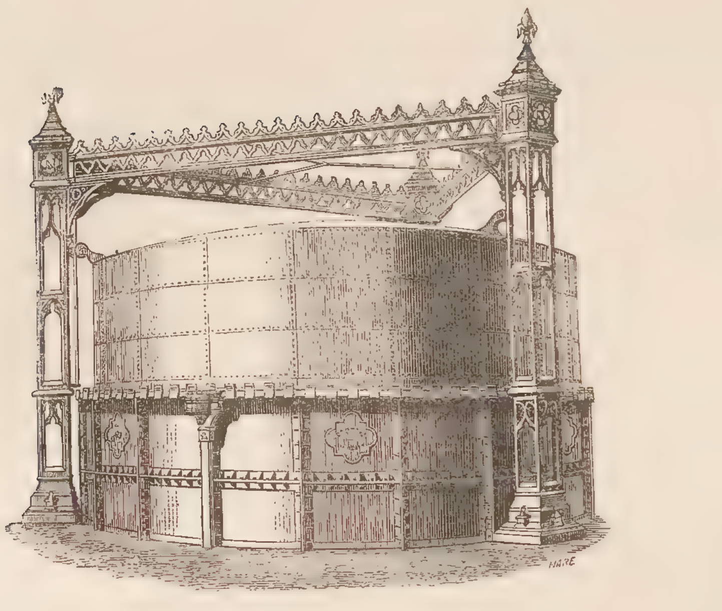
102. *Portable Gas-works* have been recently introduced with considerable success, and promise to be very useful for isolated buildings, as large mansions, farmeries, railway stations, &c. In fig. 42 we give a view of the portable gas-works manufactured by Messrs. T. B. Porter & Co. of Lincoln, and in fig. 43 a design

Fig. 42.



View of T. B. Porter's Portable Gas-work.

Fig. 43.

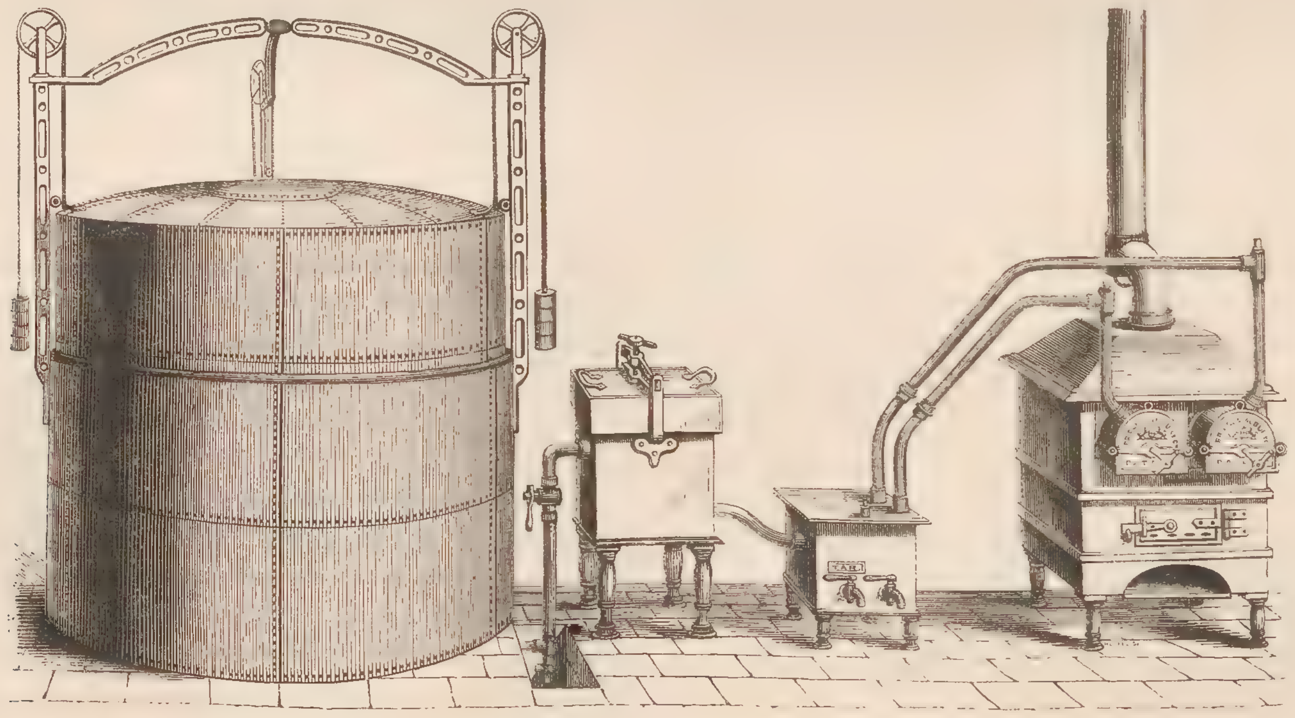


View of Ornamental Gasometer for Porter's Gas-work.

for an ornamental gasometer. Of this gas-making apparatus we here append a description which we have given elsewhere. One feature of the apparatus is the ease with which the retorts can be filled and discharged. "The retort used . . . is not of uniform diameter throughout its length like the retorts usually employed, but gradually widens from the front to the back. The back terminates at the top of a cylindrical vessel, at the foot of which a tank of water is provided; into this the coke is pushed, in the manner hereafter to be described, where, by coming in contact with the cold water, it is instantly cooled, and from which it can be removed at pleasure. The front part of the retort is of uniform diameter for some distance, and contains an Archimedean screw, which is turned by a handle placed on the end of the shaft, continued through the cover of the retort. Connected with the upper part of this end of the retort is a vertical chamber, the aperture of which is closed by a tightly-fitting stopper, which can be removed at pleasure. This chamber, or hopper, contains the charge of coal from which the gas is to be produced. On the hopper being filled with coal the stopper is put tightly in, and on turning the handle or wheel of the Archimedean screw the charge is gradually transferred from the hopper to the interior of the retort. The charge thus delivered to the retort is allowed to remain exposed to the action of the fire for about an hour. The hopper is then filled a second time, and by means of the Archimedean screw the charge is transferred from it to the retort—the second charge pushing the first charge forward into the gradually widening space of the retort. Another hour is suffered to expire, when a third charge is supplied to the hopper, and transferred to the retort pushing before it the two former charges. The fourth charge, which is in like manner made, pushes the first charge out of the wide end of the retort into the vertical chamber and its water-tank. The coke thus formed is found to be harder, denser, and consequently a more valuable kind than that resulting from the ordinary system, this arising, doubtless, from the compression to which it is subjected in being forced into the retort by the screw. In consequence of there being no escape of gas during the process of charging the retort—a loss inevitable in the old system—the quantity of gas obtained by this apparatus is greater than that produced by the usual arrangements; whilst another source of increased 'make' arises from the circumstance that the vapours evolved from the last charge introduced must all pass along the highly-heated charge or charges which precede it, and along three-fourths of the heated retort. Much of the tar produced in the old system is by this apparatus converted into gas. The purifying apparatus is of extreme simplicity, the 'hydraulic main,' the 'condenser,' and 'purifier,' all being contained in one vessel of very limited dimensions. The upper part of the figure in elevation shows the connection of the various parts—part only of the retaining wall of the gasometer being shown. The cost of the gas produced by this apparatus is stated to be 4s. 6d. per 1,000 cubic feet where a thirty light apparatus is used; where a sixty light apparatus is employed the cost will be reduced to 3s. per 1,000 cubic feet, and as much coke will be produced as will keep the fire of the retort-furnace going."

103. In fig. 44 we give an illustration of a form of portable gas apparatus, manufactured by Messrs. Carbines and Hammond of the Surrey Iron Foundry, Grove, Great Guildford Street, Southwark, London, the arrangement of which is very compact.

Fig. 44.



Carbines' and Hammond's Portable Gas Apparatus.

104. *The value of the light* obtained from the consumption of gas depends in a great measure upon the form of the "burner," or "jet," through which it issues from the pipe. Taking a plain cylindrical jet of a ¼-inch diameter, it is found that it will not give a flame higher than 2½ inches without evolving much smoke; the smoking will, however, be obviated, and the flame rendered brilliant, by simply extending or flattening out the circular aperture, so as to throw out the burning gas in the form of a thin flat body, thus exposing more of the surface to the air. The more confined and solid, so to speak, the body of the flame is, the more obscure the flame and the greater the smoke passed from it. Hence the value of the Argand burner for promoting perfect combustion, in which a ring of gas is obtained, to the interior of which air

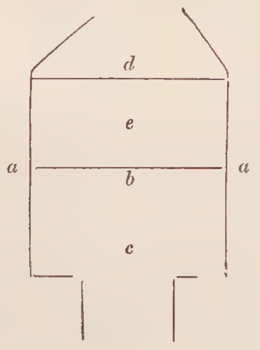
can be supplied as well as to its exterior. Although this form of jet gives a higher temperature, it appears that it does not afford so valuable a light as the "fish tail" or the "swallow tail" jets. The "fish tail" burner is made by having two small apertures in oblique directions, so that the jets cross each other. The "swallow tail" burner is formed by giving a slit or narrow aperture across the top of the jet.

105. Where chimneys are used some attention should be paid to their form, as this exercises an important influence on the consumption of the gas. Perhaps the best form of chimney is the Argand, where the diameter is suddenly contracted above the base, so that the air entering the large base is deflected—as it passes from this to the smaller tube—at a certain angle upon the flame. The following is a table showing the result of experiments made by Mr. Barlow as to "the effect of different burners when consuming Newcastle coal-gas :—

BURNERS.	Consumption per hour.	Value of 1 Cubic foot in grains of sperm.	Value of 1 cubic foot in standard candles.	Value of 8,500 feet of gas in lbs. of sperm.
1. No. 3, Fish-tail, or Union jet,	5·5	276	2·3	335
2. No. 5, Bat's-wing, . .	5·0	290	2·41	352
3. Common Argand, 15 holes, .	5·5	341	2·84	414
4. Platow's registered Argand, .	5·5	348	2·9	422
5. Bynner's Argand, . .	5·5	380	3·16	461
6. Winfield's Argand, . .	5·5	335	2·79	406
7. Leslie's Argand, . . .	4·1	369	3·07	448
8. Guise's Shadowless Argand,	5·5	364	3·03	442

"Though these experiments," Mr. Barlow observes, "indicate the relative adaptation of the several burners for the combustion of Newcastle coal-gas, they must not be taken as settling the question of the practical value of each. Some of them cast shadows which detract considerably from the light they yield *when placed above the level of the eye*; this is particularly the case with No. 5, which otherwise gives the best results. Others, like No. 7, require a more perfect uniformity of pressure, and an absence of all currents of air. Taking all things into consideration, No. 8 is perhaps the one to which these objections least apply, and it gives the next largest amount of light for the gas consumed, though the slight advance upon the old Argand, as constructed twenty-five years ago, cannot fail to be remarked."

106. While on the subject of gas-burners, it is right to notice those modifications of gas-burners known as "economic," or "economizing." In the ordinary form of gas-burner the gas —under the great, although ever-varying pressure from the gasometer at the works—rushes so quickly through the aperture to which the flame is applied—in gusts, so to speak—that the flame is blown about from side to side, giving it that flickering unsteadiness so well known and so hurtful and disagreeable to the eye-sight. A very good way to lessen this unsteadiness resulting from over-pressure is to reduce the velocity of the inflowing gas by simply placing the tap of the meter, say half open, thus reducing the flow through it. A little experience will soon show the exact amount of opening necessary. In place of adopting this plan, one of the economic gas-burners above alluded to, may be used. The principle in all of them is to admit the gas in the first place into a chamber, on passing from which to be consumed, it is made to pass over or through a diaphragm, or other resisting material. This reduces and equalizes the velocity, the gas passing out in a quiet, steady way, so that it is consumed without flickering. The following diagram illustrates one arrangement of this form of gas-burner, where *a a* represents the chamber into which the gas is admitted; this has within it two perforated diaphragms *b* and *d*, between which a piece of loose felt *e* is placed, and which can be compressed by a small screw stud passing through both diaphragms. The space *c* is filled with loose felt to absorb such impurities as may be in the gas. This diagram illustrates the arrangement of "Hart's (of London) Economizing Gas-burner."



107. In the lighting of large apartments perhaps no apparatus or arrangement is so successful and satisfactory as that known as the "sun-light." This was invented—although other claims have been made to the invention—by Mr. King of Liverpool. The following is a description given of it in Mr. Clegg's work.* "The sun-burner, introduced by Mr. King, and first applied by him to light the public buildings of Liverpool, produces the most brilliant effects of gas illumination. It consists of a combination of six or more fish-tail burners, fixed horizontally in a circle to form a star, and several of these stars are then combined together in a splendid constellation. This burner, as usually constructed, is fixed near the ceiling, and two concentric chimneys carry off the products of combustion to the external air. In the construction of the chimneys there is a remarkable peculiarity, for the purpose of making the flames of the jets of gas horizontal, so that they may throw the light directly down instead of turning upwards, as they would do if the draught of air passed between the jets into an ordinary chimney. The lower part of the inner chimney is conical, or trumpet-shaped, and covers all the burners. It rises about three feet within the chimney that encloses it, the bottom of which is also conical. The products of combustion are not allowed to escape unobstructed through the inner chimney, for near the top there is a throttle-valve, which is so adjusted as to pass only one-fourth of the gases and vapour, the remaining three-fourths being reflected upon the back part of the flames, and, flowing over the lower edge of the inner chimney, are carried off through the outer one into the air. This regurgitation of the heated air and vapour forms a horizontal ring of flame round each jet, and the combination of these in a sun-burner of seven stars, seen from below, produces a beautiful effect. . . In the sun-burner, as thus described, some inconvenience is experienced, especially when the burner is placed lower than the ceiling, by the shadow of the chimney, which throws the upper part of the room into gloom, and by the entrance of cold air when the gas is not lighted. To remedy the first inconvenience Mr. Strode has made openings in the lower parts of the chimney, which are filled in with talc, and the access of cold air is prevented by an ingenious application of a regulating gas-holder to work a butterfly-valve. By this means, as soon as the gas is turned on, it rushes up the tube, and raises the cover of the gas-holder, which is sealed by mercury, and in rising it opens the valve. On shutting off the gas the contrary effect is produced, for then the valve is closed and the air is excluded."

108. A method has recently been patented for increasing the illuminating powers of coal gas, by passing a stream of it over a quantity of naphtha on its way to the jet where it is to be consumed. A public company which works the patent is carrying the plan out in several of the street lamps of the city of London. Opinion is, however, very much divided as to the merits of the plan.

109. A very important part of what may be called the science of artificial lighting is the "art of measuring the relative intensities of lights" from various sources. This is called

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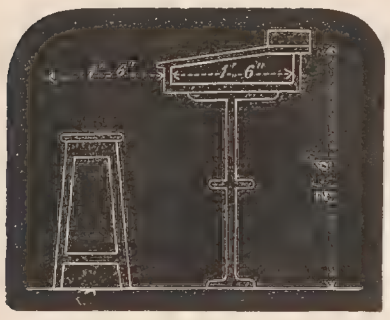
* A Practical Treatise on the Manufacture and Distribution of Coal Gas, its Introduction and Progressive Improvement, illustrated by engravings from Working Drawings, with general estimates. Third Edition. London: Weale.

photometry, and the instrument by which the measurement is made is called a photometer. From the nature of light it is obvious that we cannot make it register its own value by giving motion to any contrivance. "This," says Professor Herschel in the *Encyclopædia Metropolitana*, "obliges us to refer all our estimations of the degrees of brightness at once to our organs of vision, and to judge of their amount by the impression they produce immediately on our sense of sight. But the eye, though sensible to an astonishing range of different degrees of illumination, is partly on that very account but little capable of judging of their relative strength, or even of recognizing their identity, when presented at intervals of time, especially at distant intervals. In this manner the judgment of the eye is little to be depended on for a measure of light, as that of the hand would be for the weight of a body casually presented. This uncertainty, too, is increased by the nature of the organ itself, which is in a constant state of fluctuation, the opening of the pupil which admits the light being continually contracting and expanding by the stimulus of the light itself, and the sensibility of the nerves, which feel the impression varying at every instant. Let any one call to mind the blinding and overpowering effect of a flash of lightning on a dark night compared with the sensation an equally vivid flash produces in full daylight. In the one case the eye is painfully affected, and the violent agitation into which the nerves of the retina are thrown is sensible for many seconds afterwards in a series of imaginary alternations of light and darkness. By day no such effect is produced, and we trace the course of the flash, and the zig-zags of its motion, with perfect distinctness and tranquillity, and without any of those ideas of overpowering intensities which previous and subsequent total darkness attach to it. But yet more. When two unequally illuminated objects (surface of white paper, for instance) are presented at once to the sight, though we pronounce immediately on the existence of a difference, and see that one is brighter than the other, we are quite unable to say what is the proportion between them. Illuminate half a sheet of paper by the light of one candle, and the other half by that of several, the difference will be evident. But if ten different persons are desired, from their appearance only, to guess at the number of candles shining on each, the probability is that no two will agree. Nay, even the same person at different times will form different judgments. This throws additional difficulty in the way of photometrical estimation, and would seem to render this one of the most delicate and difficult departments of optics. Mr. Tomlinson, in his admirable "Cyclopædia of Useful Arts," in giving this extract, thus comments upon it:—"The eye is, however," he says, "able to judge with tolerable accuracy of the equality of two lights, or of two degrees of illumination seen at once. Thus, in order to ascertain the relative quantities of light furnished by two different lamps, place two discs of white paper a few feet apart on a wall, and throw the light of one lamp upon one disc and the light of the other lamp upon the other disc; if the lamps are of unequal illuminating power, the lamp which affords most light must be moved back until the two discs are equally illuminated. Then, on measuring the distance between each lamp and the disc which it illumines, the luminous intensities of the two lamps may be calculated. As the intensity of light from a point, or luminous source, diminishes inversely with the square of the distance . . . so the intensities of the two lamps are to each other as the square of the distance. If, when the discs are equally illuminated, the distance from one lamp to its disc is double the distance of the other lamp from its disc, then the first lamp is four times more luminous than the second; if the distance be triple, it is nine times more luminous, and so on." Ingenious as this plan is, it is, however, obvious that its results are only approximative, for it will be difficult, as Professor Herschel points out, for the eye to decide when the two discs are equally illuminated. The approximative results obtained by this method will, however, be sufficiently useful for many practical purposes.

ON THE ARRANGEMENT AND CONSTRUCTION OF SCHOOLS.

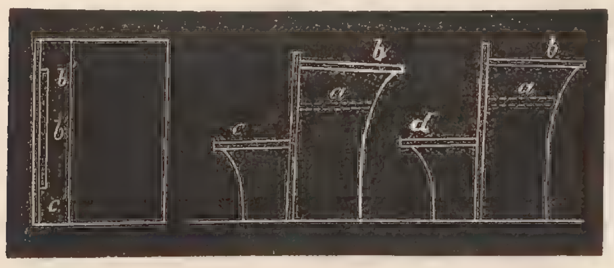
Fig. 34.



Master's Desk and Stool.

standard to be of iron, and to have an inch deal shelf 12 inches by 8 inches. The *platform* on which the desk stands is to be inch deal, on bearers 5 inches by 2 inches, moulded nosings, inch risers, the corners to be rounded with large quadrant sweep. In fig. 35 we illustrate the mode of making a combined desk and form, stated by Mr. Barnard—by whom the plan is given—to be the cheapest form.

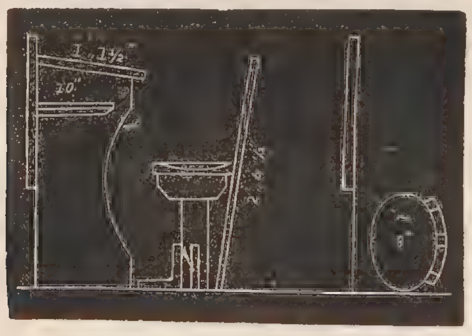
Fig. 35.



Wooden Desks for one or two Pupils.

Each desk is designed to accommodate two pupils, and its height may vary from 28 to 29 inches from the floor to the top for the oldest, and from 20 to 21 inches for the youngest pupils. The seat may vary correspondingly in height from the floor from 17 to 18 inches to 9½ to 10 inches. The top of the desk should be 4 feet in length, 2 feet for each pupil. The upper surface *b* should slope 1 inch in a foot; but the part *b′ b′* should be flat, and 3 inches broad. In this an opening should be made to receive the slates, and a circular hole should be made at each end, as at *c′*, to receive the ink bottles. Each desk is furnished with a shelf, as *a a*, to hold books. The seat, as *c* and *d*, is fixed to the front of each desk.

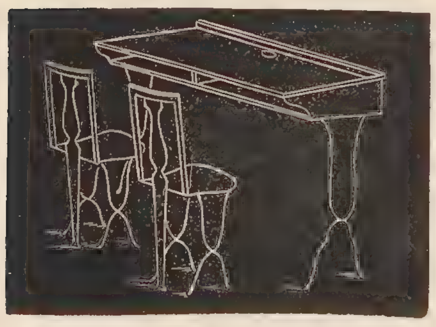
Fig. 36.



Desk and Chair for one or two Pupils.

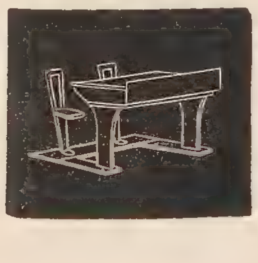
In fig. 36 we illustrate another form of desk with form for two pupils, with dimensions marked, and with plan of bottom of form for one pupil. In fig. 37 an illustration from Barnard's work is given of the form of desk and chair known as the "Albany Normal School Chair and Desk." In these the standards are of iron; the form shown in fig. 38 is altogether of wood.

Fig. 37.



American form of Desks and Chairs for 2 Pupils, with Iron Standards.

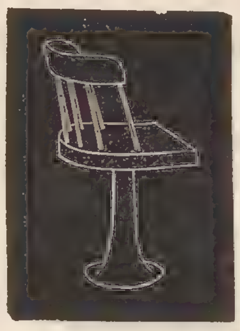
Fig. 38.



American form of Desks and Chairs with Wood Standards.

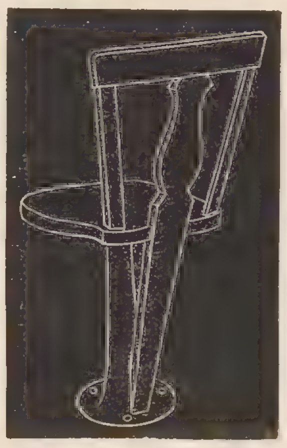
Figs. 39 and 40 are forms of chairs introduced by Mr. Ross, and illustrated by Mr. Barnard.

Fig. 39.



American School Chair.

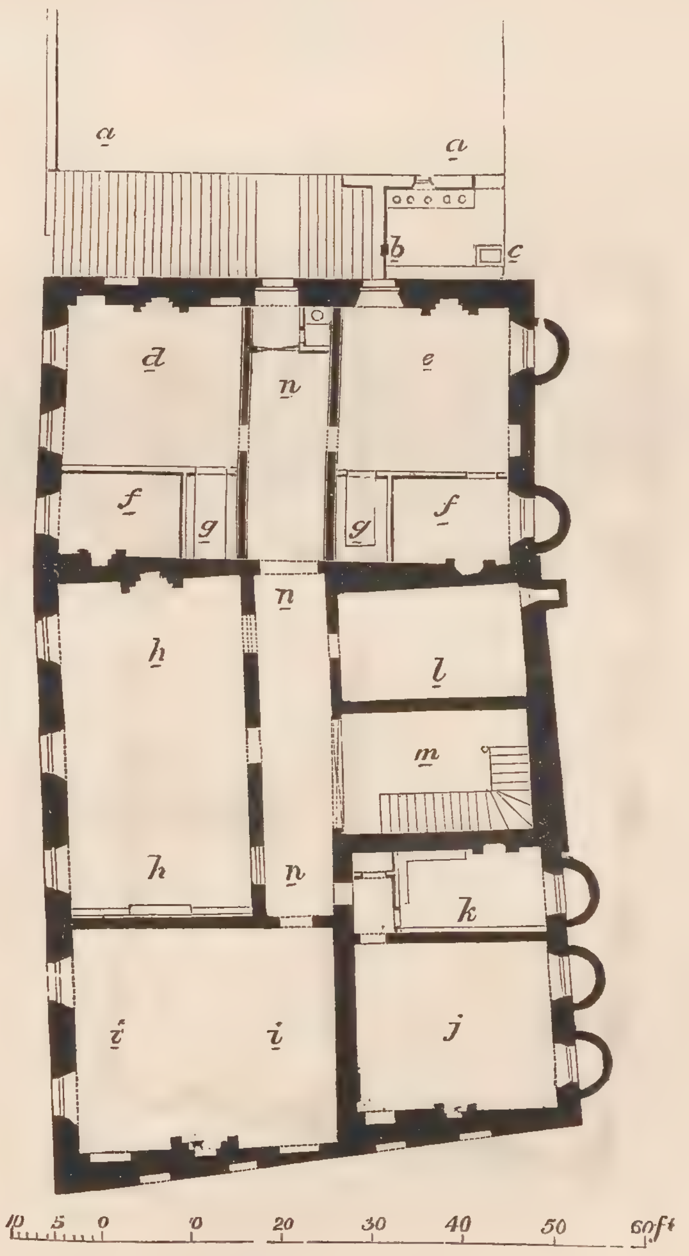
Fig. 40.



American School Chair.

In the Boston Primary School-house ordinary arm-chairs are used for the pupils, and are provided with racks fastened to the sides, in which books and slates can be placed. They are not fastened to the floor, but can be moved from place to place. Their use has been attended with such results that the school committee has recommended their adoption in all the schools of Boston, to the exclusion of all other forms. As a useful conclusion to our remarks, we give here the plans of the Edinburgh Normal School, as given by and arranged under the superintendence of the Governmental Department of Education.

Fig. 41.



In fig. 41, which is the plan of floor under level of Castle Place, *a a* is the open bank for play-ground; *b* children's privy under stairs; *c* a sink; *d* is the teacher's parlour 20 feet by 20 feet; *e* the housekeeper's room, 20 feet by 19 feet; *f f* bed-room off ditto; *g g* closets ditto; *h h* library, 38 feet by 21 feet; *i i* dining hall, 30 feet by 25 feet; *j* store room, 22 feet by 20 feet; *k* pantry; *l* cellar; *m* staircase;

Fig. 42.

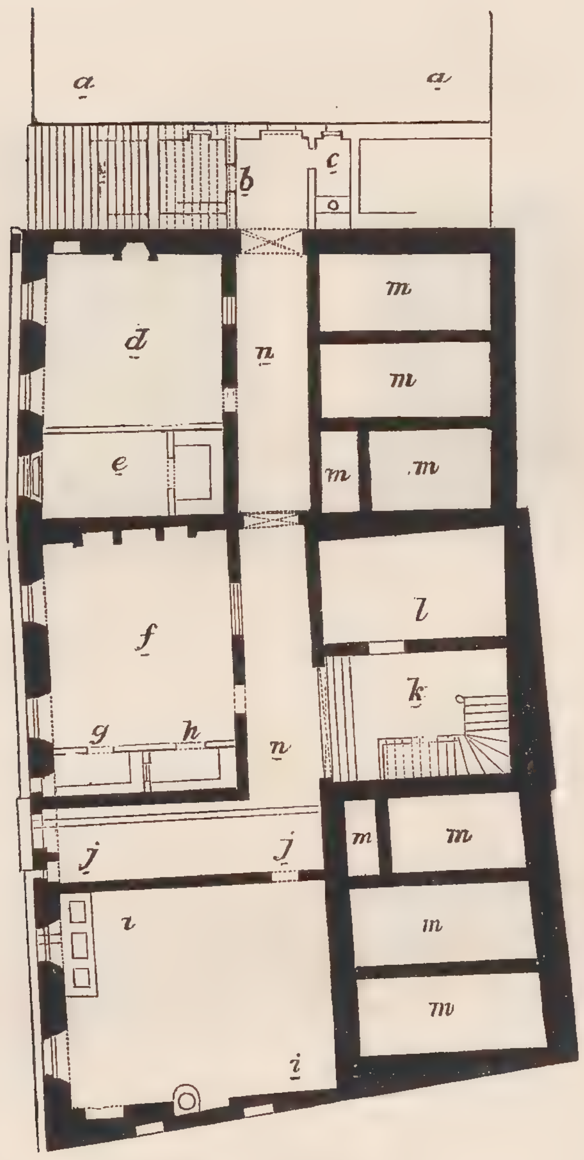


Fig. 43.

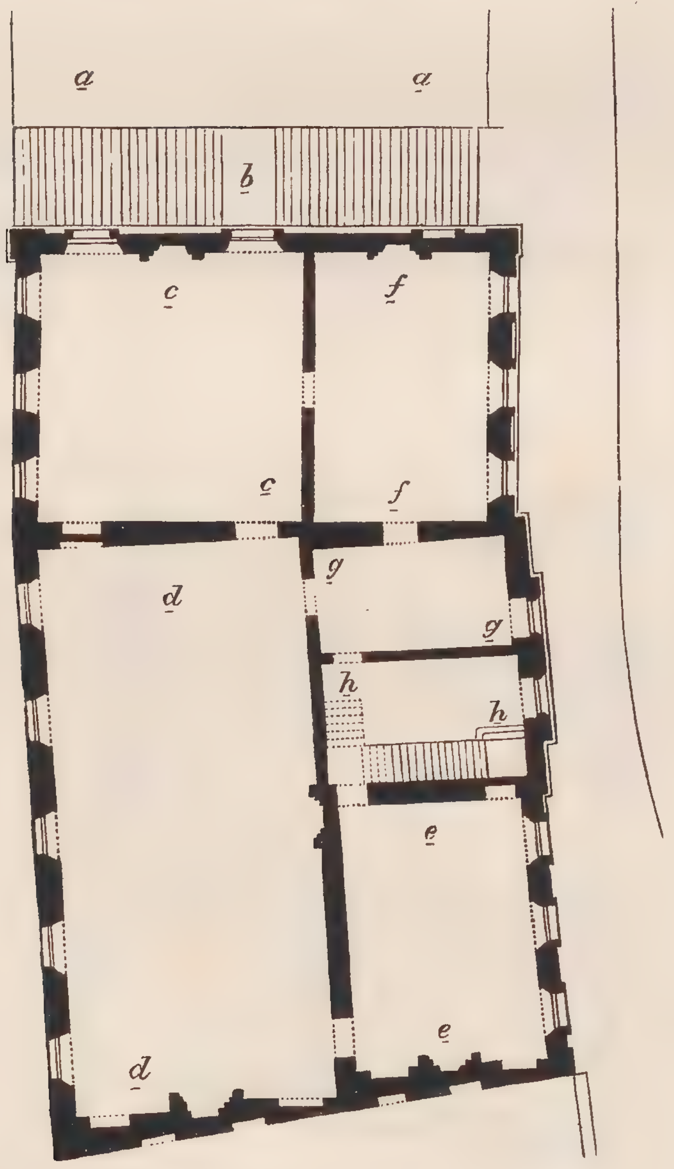
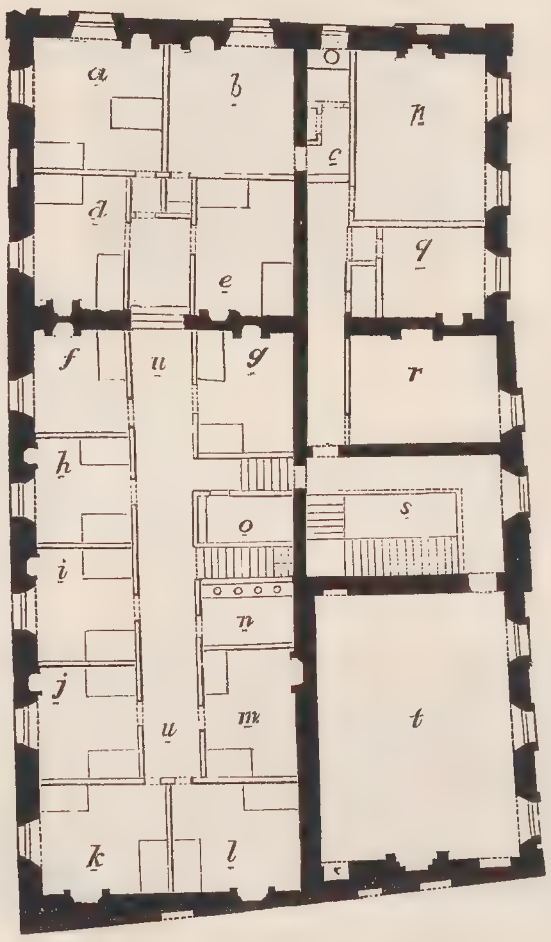


Fig. 44.



n n n passage. In fig. 42, which is a "plan of ground floor on the level of Currie's Close," *a a* is the open bank; *b* the larder; *c* water-closet; *d* servants' room, 20 feet by 20 feet; *e* scullery, with pantry off it; *f* kitchen, 23 feet 6 inches by 21 feet, with pantry *g* and closet *h* off it; *i i* washing-house and laundry, 30 feet by 25 feet; *j j* kitchen entrance; *k* cellar under staircase; *l l* coal cellar; *m m m m m m m m* foundations; *n n* passage. In fig. 43, which is a "plan of the principal floor on the level of Castle Place," *a a* is the open bank; *b b* Castle Wynd stairs; *c c* class-room, 30 feet by 30 feet (20 feet high); *d d* public school-room, 65 feet by 30 feet (20 feet high); *e e* class-room, 30 feet by 22 feet; *f f* ditto, 30 feet by 20 feet; *g g* school lobby, 21 feet 6 inches by 12 feet 6 inches; *h h* house lobby and stairs, 22 feet 6 inches by 14 feet. In fig. 44, which is a "plan of upper floor," *a* bed-room, 14 feet 6 inches by 14 feet 6 inches; *b* rector's bed-room, 15 feet by 14 feet 6 inches; *c* water-closet; *d e* bed-rooms, 15 feet by 11 feet; *f* teacher's bed-room, 12 feet by 11 feet; *g* ditto, 14 feet 6 inches by 11 feet; *h* ditto, 12 feet by 11 feet; *i* and *j* ditto, ditto, each 13 feet by 11 feet; *k l* ditto, 14 feet 9 inches by 13 feet; *m* ditto, 15 feet by 11 feet; *n* washing closet; *o* housemaid's closet; *p* dining-room, 19 feet 6 inches by 15 feet; *q* bed-room, 12 feet by 10 feet; *r* kitchen, 17 feet by 12 feet 6 inches; *s* well-hole of stairs; *t t* committee-room, 30 feet by 22 feet; *u u* passage, 7 feet wide. The apartments *b*, *c*, *p*, *q*, and *r*, are the rector's.

25. We have thus gathered together from various quarters a variety of notes, hints, and illustrations, on the important subject of the arrangement, construction, and fittings of school-houses, which may be useful as conveying—to those of our readers who have not hitherto had their attention directed to the subject—a fair notion of what the best authorities deem essential to be remembered in connection with it.

THE DRAINAGE OF TOWN AND RURAL DISTRICTS AND BUILDING SITES.

STREET, ROAD, AND HOUSE SEWERS AND DRAINS.

1. It is impossible to over-estimate the importance of efficient means for rapidly withdrawing from the immediate neighbourhood of dwelling-houses the excretæ and the waste and refuse matters of their inhabitants. Not only are these matters, when they are allowed to remain within the precincts, or to stagnate around the exterior of our houses, offensive to the eye, and indicative to a greater or less extent of a low *morale* on the part of those witnessing them, but they become an immediate and direct cause of disease. For it may be now taken as an axiom that the "immediate and direct cause of fever is a poison generated by the decomposition of animal and vegetable matter;" and when these are allowed to remain near our dwelling-houses, that result may be considered inevitable which the sanitary history of the last twenty years has so clearly shown us. Yet well-established as this truth now is, that dirt and disease, filth and fever, are inevitable concomitants, it is nevertheless remarkable for how long a period we were nationally ignorant, or at least, if cognizant of, indifferent to it. Up to a comparatively recent period no attention was paid to house and very little to street drainage, the whole of the latter being confined to the side kennels, or gutters, with now and then a gigantic sewer, in the construction of which all hydraulic laws were generally set at defiance, this being placed in the centre of the street, and into which the side kennels emptied themselves. Systematic connection — by means of small drains—of the houses with this central drain or sewer, was rarely thought of.

2. The principal feature of the modern system of town drainage, is the use of *water* as a vehicle by which the waste matter of our houses is carried off as rapidly as possible, and the principle on which it proceeds may be stated thus—*the quicker all matter is conveyed from the neighbourhood of man's dwellings the better.* The origin of this water system seems to have been somewhat as follows:—In early times, when the population was small, and their dwellings were thinly scattered here and there, the neighbourhood of a river was, for many obvious reasons, chosen as their sites. Closely situated to the river's banks, the refuse of their houses was naturally thrown into its stream, which found at once the most obvious and effectual carrier. But as the population increased, and their dwellings crushed in upon one another, many were forced to be built at a considerable distance from the stream. Labour is always grudged where labour is disagreeable, or can by any easy method be avoided; the daily journey to the river to throw in the refuse was therefore in time given over, and the end was served, or endeavoured to be served, by the digging of a hole—or the raising of a dung heap—into which the refuse was thrown, or upon which it was heaped. But the holes—called "cess," hence our modern cesspools—in time overflowed; and to lead the matter thus collected to the river, ruts, or open drains, were made in the ground. These, spreading around, odours—not by any means suggestive of the

> "Sabean odours from the spicy shore
> Of Araby the blest,"—

were then covered up in order to abate the nuisance to sight, if not to smell; and as the matters stagnating therein were in process of time found to block up the channels, water was doubtless often poured down them to clear them out. Population still increasing, the number of cesspools increased also, and, in like degree, the size of the channels or sewers. In all cases the final place of deposit was the river or the sea. Huge, ultimately, in dimensions, and faulty in construction, these sewers, or drains, leading to the river or the sea, became in course of time vast receptacles of noxious and dangerous gases, which found easy access to the upper air through the gully-holes which were placed here and there to allow of the surface water, &c., &c., of the streets to be passed into their interior. "Then came," as we have elsewhere remarked, "the disease, and so the search for the remedy. It very soon became evident that the decomposing matter thus poisoning the air was most assuredly the 'wrong thing in the wrong place.' The first impulse was to get rid of it. Where? No matter—get rid of it. How? Then the recollection of the old river-carrier flashed across men's minds, and 'Water! Water!' was the cry. It is easy to understand how so mobile a vehicle as water would be at once taken as the best for conveying quickly away the sewage of our towns, and so it was; a most elaborate system of pipe drainage was instituted and carried out wherever it could be adopted, by which the refuse of a house was conveyed to the sewers, and that of the sewers to the river, the removal being effected mainly by the aid of water."

3. In considering the subject of street sewers and house drains, it naturally divides itself into two parts—first, their "form;" and, second, their "size." For a long period, the form used was that having square sides and bottom, as *a b c d*,

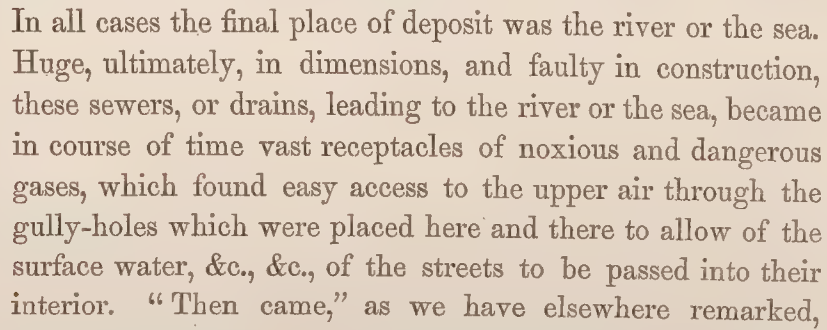
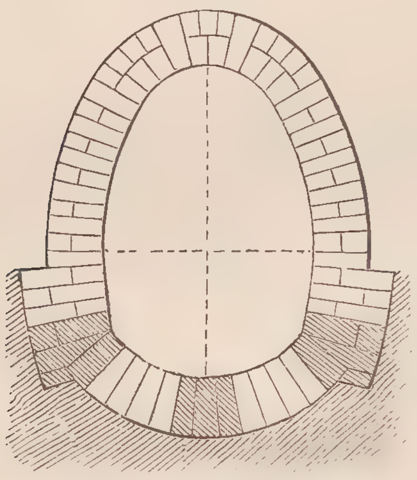


Fig. 1. Fig. 2.

Old forms of sewers, with flat sides and bottom (1), and curved top and bottom and flat sides (2).

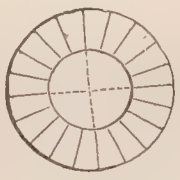
fig. 1; where the drain, or sewer, was large, the cover, in place of a flat stone, as *e*, was replaced by an arched top of brickwork, as shown in the dotted lines *f f*. The first improvement in the form was somewhat as shown in fig. 2, and another form is that shown in fig. 3, where the sides are arched as well as the top and bottom. The next step was obviously the egg-shape, as illustrated in numerous sizes in Plate XXXIX; and in which Plate also will be found in fig. 5 a method of describing the curves of this form. The circular form, as shown in fig. 4, is also now greatly used, but made of earthenware in place of bricks, as in the fig. For long the sewer with flat sides and bottom was considered in every way the best; and even after experience had demonstrated plainly enough that it was not only weak—(whole lengths of sewers of even the more improved forms, as shown in fig. 2, having had their sides forced in with the pressure of the earth as illustrated in fig. 5)—but that in addition to being weak, the great disadvantage was also obtained by it of the sluggish nature of the stream of sewage passing through it, and the rapidity with which the interior became wholly or partially filled with solid deposit, as shown by the dotted surfaces in figs. 1, 2.

Fig. 3.



Sewer with curved sides, top and bottom.

Fig. 4.



Circular Brick Sewer.

Fig. 5.

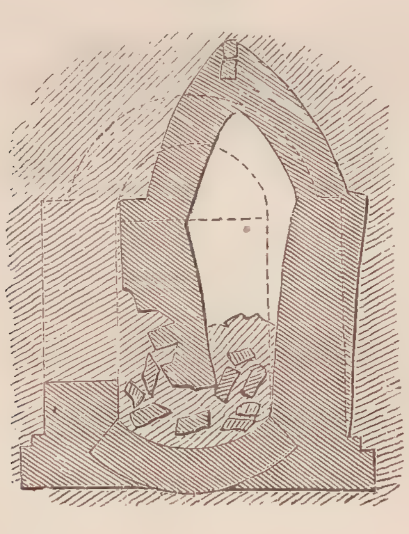


Diagram illustrating effects of lateral pressure on weak form of sewer.

4. It is now an established point that the circular form of channel is better adapted for the flow of water than the flat. Mr. Roe, the surveyor of the Holborn district of drains in London, and who was one of the first to bring into notice the improved forms now in use, states that by the alteration of the form from a flat segment, as in fig. 1, to that of the egg-shape, as in Plate XXXIX., fig. 4, with the same quantity of water and the same inclination, the quantity of deposited matter was reduced one-half. In a circle, the proportion of surface is smaller, while its capacity is larger than any other shaped tube as a square. Thus, the surface of a circular tube 2 feet 3 inches in diameter—giving an opening of 4 square feet in surface—would be 7 feet, this representing the surface or cause of friction, in the water flowing through it, while a square tube, 2 feet by 2 feet, would give a surface, or cause of friction, of ten feet. But the advantage which the egg-shape has over the circular, is nearly as great as the circular has over the square tube, in this respect, that it has an increased scouring action, derived from the greater rapidity of flow, when the stream, passing through it, is small; for, whatever be its amount, it is always flowing over a circular surface. For small drains, however, the circular drain, if not the best in form, is at all events the easiest laid down, the egg-shape tubes offering a greater difficulty in forming their junctions than the circular tubes.

5. Another advantage possessed by the large egg-shaped drains over those as in fig. 2, is that a less quantity of material is required to build them. Thus, the number of bricks required to build 6 feet 3 inches of a sewer of the shape as in fig. 2, would build 10 feet 2 inches of an egg-shaped sewer as in fig. 4, Plate XXXIX., both having the same cubical capacity.

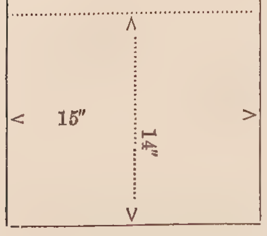
6. We now come to the *size* of the drains. For long the size was decided upon by mere empirical rules, if indeed, rules of any kind were at all considered. In the majority of cases, doubtless, hap-hazard conjecture was alone trusted to. Errors, therefore, crept rapidly into this branch of engineering, but these were, however, rarely in the direction of making the drains too small. They were, on the contrary, as a rule, too large. The result was, that not only was a vast quantity of material uselessly expended in their construction, but the worst feature was, their very utility as "carriers" was jeopardized, inasmuch as the solid matter of the sewage was so quickly deposited that the sewers were in many cases blocked up, and served as receptacles to retain rather than as means for conveying away the nauseous products of our domestic arrangements. One reason why our drains and sewers were made so enormously large was ignorance, to no small extent wide-spread, of correct hydraulic principles.

> "It accounts," says the Report of the Board of Health on Drainage while treating of this point, "in part for the singular want of agreement among the opinions and reports put forth, even by persons whose duty it was to understand the subject well, respecting the laws of water currents in open or close channels, to observe that, as in hydrostatics, some of the phenomena depending on the mere weight and diffused pressure of water, appear so extraordinary to persons beginning the study, or imperfectly acquainted with the laws, that such phenomena have been called 'hydrostatic paradoxes;' so, in hydraulics, some simple consequences of the well-known laws of falling bodies, and of atmospheric pressure, are so unexpected and unintelligible to ordinary conception as to deserve similarly the appellation of 'hydraulic paradoxes.' One of these last is the fact that a uniform, sufficiently-sloping, open channel, which, at its top, is freely receiving from a reservoir, or a meeting of currents, so much water as completely to fill its mouth, can yet receive into its stream lower down large additional quantities of water through lateral inlets, and will then discharge from its bottom opening—which is of the same size as the top opening—even several times as much water as entered at the top. Another of these 'paradoxes' is the fact, that if a common funnel, or a short piece of tube with a gaping mouth, be held under a water-cock, and as much water be allowed to fall into it as to maintain it nearly full, and then if a pipe of the same diameter as the lower outlet of the funnel, or piece of tube, be joined to it so as to lengthen it below, the quantity of water passing through, instead of being lessened by the friction of the additional downward pipe—as hap-

pens when an addition is made of horizontal pipe—will be increased in a proportion to the length of pipe added, until that length reach a level of about 34 feet below that of the mouth of the apparatus. A water-column of 34 feet has a pressure nearly that of the atmosphere. The first of these remarkable facts is a simple consequence of the law known to everybody, that a body falling freely is always increasing its speed, whether its course be directly down—as of an apple from a tree, with increase of speed of 32 feet per second—or be oblique, as when a railway carriage, carelessly left loose at the top of a steep slope, gets away, and soon has a velocity which dashes it to pieces against any obstacle met below (the increasing speed in such a case being proportioned to the steepness of the slope or incline); and whether the descending body be solid, as in the cases just mentioned, or fluid, as in the water of a perpendicular cascade, or in that of rapids shooting along sloping portions of a river channel. The phenomenon of the acceleration of a fluid current under the continued influence of gravitation is well shown where a viscid fluid, like treacle, is poured from a height. A mass, at first slow moving, and as bulky as a man's wrist, may be seen gradually tapering as it descends to the size of a finger, or less, the diminution of size being everywhere exactly proportionate to the increase of speed; and however long the experiment be continued the tapering cascade retains the same form. Similarly, a water stream, in a sufficiently sloping, uniform channel, becomes less bulky as it descends and as the speed increases, although, of course, the same quantity of water passes along every portion of the channel; and hence a larger space, or area of the uniform channel, is left unoccupied by the water as the speed of this increases, and so more room is left for additional streams to enter the channel from around its descending course; because, however friction of the water against the sides of the channel increases rapidly as the speed of the current increases, while the force of gravity tending to accelerate remains the same, a state of equilibrium is soon reached between these opposing forces; after which the stream, however long, goes on uniformly, with speed proportioned to the slope. This is seen in all rivers of uniform current. In the annexed wood-cut are sketched sections at three points of a sloping pipe, in which a stream was running, and becoming less bulky as the speed increased. The other hydraulic paradox above mentioned, of a common funnel, or gaping short piece of pipe, and, in certain cases, of water-drains, being caused by having an addition of pipe made at the lower opening to transmit much more water than what fills the mouth, which pipe may be either perpendicular or oblique, is owing to the disturbance of the atmospheric pressure which is acting on all things at the surface of the earth, and therefore on the top and bottom of the column of water in the pipes. It happens thus:—In the cases supposed, the descending stream, if free, would quicken its speed, and become lessened in bulk in its descent (as already explained above for open channels, or for free descent in the air); but in a long tube, having openings only at the top and bottom, and both openings filled with water, the stream cannot lessen its bulk without leaving a vacuum in the tube, which vacuum the pressure of the atmosphere at the top and bottom tends to prevent. Thus, therefore, the part of the tube below, as well as that above, is kept full of water, the weight of which balances or destroys more or less of the upward atmospheric pressure at the lower opening, and lets the undiminished atmospheric pressure above, act as an unopposed force, to urge more water through. If the tube below had its mouth exposed to the air (that is, were not immersed in water), and were roomy enough to allow a stream of air to ascend by the sides of the stream of water descending, no increase of water flux through the general tube would be produced by an addition of tube below."

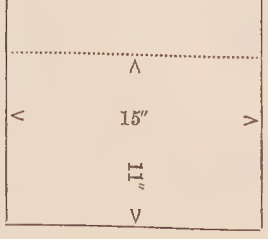
"In illustration of the above may be given the following instance of one trial:—

No. 1.
Sectional area of water 10 feet from inlet.



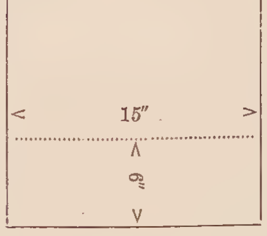
Water being 14 inches in the pipe.

No. 2.
Sectional area of water at mid-channel.



Water being 11 inches in the pipe.

No. 3.
Sectional area of water at outlet.



Water being 6 inches in the pipe.

"*Velocity* and *amount* of water flowing through 235 feet of 15-inch earthenware pipe, temporarily laid at Hitchin, at an inclination of 8 inches in the 235 feet, or 1 in 352½, an opening being made for the admission of air at the centre of the pipe."

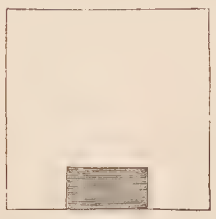
"The velocity of stream was about 188 feet per minute, and the amount of water discharged 1,025 gallons per minute, or 1,476,000 gallons in twenty-four hours. The gauging of No. 1 section was taken 10 feet from the inlet to secure the fair current of water, the pipe being full at the outer end."

"In respect to town drainage, the practice of architects and engineers was to enlarge the area of each junction into it, whereas, it was found by the trial works that the addition of eight junctions, each of 3 inches diameter, into a main line of pipe of only 4 inches diameter, so increased the velocity of the stream that there was no increase of its sectional area."—(*Appendix No. 2, to Report on Water Supply; Medworth*, p. 191.)

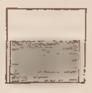
"Enormous works have been constructed in neglect of these principles, and at worse than double the cost to the public."

7. "It is important," says the Report in another place, "that the result of inquiry on this point should be understood, namely, why a small channel, or drain, properly adjusted to the run of water to be discharged, will be kept clear; while a large channel, with the same quantity of water to be discharged, and with the same fall, or inclination, will accumulate deposit.

"In large drains, a given run of water is spread in a thin sheet, which is shallow in proportion as the bottom of the drain is wide; hence friction is increased, the rate of flow retarded, and, according to a natural law, matters at first held in suspension, and which a quicker stream would carry forward, are deposited. If there be any elevated substance, the shallow and low stream, having less velocity and power of floating or propelling a solid body, passes by it. Thus, if by any neglect substances not intended to be received by a drain enter it—for instance, if a scrubbing-brush or hearth-stone has been allowed to get into, say a 15-inch drain, the height of water in regard to such substance may be as in the following sketch.



"But if it were a 4-inch drain, the same quantity of water would assume a very different relative position, as in this smaller sketch; and



it will be readily understood that the deeper stream of the contracted channel would be more powerful to remove any obstructing body.

"Instead of concentrating the flow of small streams, and economizing their force, the common practice is to spread them over uneven surfaces, which 'deadens' and 'kills' them.

"In a small drain an obstruction raises an accumulation of water immediately, which increases according to the size of the obstruction, until four, five, or six times more hydraulic pressure is brought to bear for its removal than could by any possibility be the case in a large drain; for in a large drain of three or four times the internal capacity, the water can only be dammed up to the same relative height by an accumulation of matter three or four times higher, and therefore 27 or 64 times greater, which will gradually lengthen out, as shown in the following sketch, and then be beyond the power of removal by the water:—

"Earthenware pipes, if properly constructed, and non-absorbent, wear away less than brick drains do, and much less frequently want repair.

"From their reduced size, less earth has to be excavated from a narrower trench, and they may be laid more quickly and with more certainty than the common brick drains. Rats cannot work through earthen pipes; and as, when properly laid, they detain no deposit, and when smoothly made give no foot-hold, they afford neither food nor shelter for such mischievous vermin."

8. But while care should be taken not to make the drains too large, care is no less demanded to avoid running into the opposite extreme, and making them too small. The epidemic which broke out at Croyden so suddenly some years ago, and which was traced to the drains, which were too small to convey away the sewage, reads us a lesson in this matter. Mr.

Page, the now eminent engineer, was sent to report upon the subject, and in this report he has the following, with reference to the reasoning which, in par. 7, we have given:—"No one," he says, "will doubt the correctness of this reasoning in favour of the 4-inch pipe as far as it goes; but unfortunately it does not go far enough, for if two scrubbing-brushes, or two hearthstones, or any two of the various classes of substances which are washed into the pipe sewers, should be supposed to meet in the 4-inch pipe sewer, into which so many 4-inch house drains discharge them, the 6-inch or 8-inch pipe would have the advantage over the 4-inch pipe, and if each of the numerous house-drains were to supply simultaneously its contribution towards an obstruction, whether it were a 'night-cap,' or a 'piece of flannel,' or a 'kitten,' or any one of the stoppages at Croyden, then not only would the 10-inch or 12-inch pipe be insufficient for the conveyance of these matters to the outfall, but the 11-inch pipe also; and, as in many of the districts drained, whether by pipes or brick sewers, the habits and knowledge of the population are such as to render them averse to, or unfitted for, such sanitary arrangements as require systematic treatment; and as the population cannot hastily be fitted up for the sewerage, the sewerage must be fitted up, in a degree, for the population. Another important element, besides the simple hydraulic one, forces itself, or ought to force itself, upon the attention of those who are laying down mains for such important improvements as sewerage and drainage, namely, the *requirement of the population for whom the works are intended.*"

9. The following table is specially calculated by Mr. Roe for house and court drainage. It shows the size and inclination of main house-drains for given surfaces, the number of houses of either rate thereon, and calculated for a fall of rain of 2 inches in the hour, as obtaining in the Holborn and Finsbury districts. We take the table from the Board of Health Reports:—

Surface occupied.		Number of houses of either rule, either of which may be respectively drained.				Diameter and Inclination of Tubes.									
Acres.	Squares of 100 feet.	1st.	2d.	3d.	4th.	3 inch.	4 inch.	5 inch.	6 inch.	7 inch.	8 inch.	9 inch.	12 inch.	15 inch.	18 inch.
$\frac{1}{8}$	54	1	2	3	4	1 in 120									
$\frac{1}{4}$	112	2	4	6	9	1 in 20	1 in 120								
$\frac{7}{16}$	195	3	7	10	15	....	1 in 40								
$\frac{1}{2}$	224	5	8	13	18	....	1 in 30	1 in 80							
$\frac{6}{10}$	265	5	9	15	21	....	1 in 20	1 in 60							
1	448	10	15	26	36	....	....	1 in 20	1 in 60						
$1\frac{1}{5}$	528	11	17	29	40	....	....	....	1 in 40	1 in 120					
$1\frac{1}{2}$	648	15	23	39	54	....	....	....	1 in 20	1 in 60	1 in 120				
$1\frac{4}{5}$	814	19	28	49	67	....	....	....	....	....	1 in 80				
$2\frac{1}{10}$	912	21	32	55	76	....	....	....	....	....	1 in 60	1 in 120			
$2\frac{1}{2}$	1094	25	38	65	90	....	....	....	....	....	....	1 in 80			
$2\frac{3}{4}$	1200	27	42	71	99	....	....	....	....	....	....	1 in 60			
$4\frac{1}{2}$	1970	45	68	117	162	....	....	....	....	....	....	....	1 in 120		
$5\frac{3}{10}$	2308	52	79	136	189	....	....	....	....	....	....	....	1 in 80		
$5\frac{4}{5}$	2534	59	88	150	208	....	....	....	....	....	....	....	1 in 60	1 in 240	
$7\frac{4}{5}$	3432	79	118	205	284	....	....	....	....	....	....	....	....	1 in 120	
9	3976	90	135	234	324	....	....	....	....	....	....	....	....	1 in 80	
10	4404	101	152	263	364	....	....	....	....	....	....	....	....	1 in 60	1 in 240
17	7400	169	253	439	608	....	....	....	....	....	....	....	....	....	1 in 120
$19\frac{1}{10}$	8700	200	300	520	720	....	....	....	....	....	....	....	....	....	1 in 60

10. This table will be useful for approximative estimates; but it should not be forgotten, that while published tables may be useful for the districts similar to those in which the experiments were made on which these tables were founded, they are not trustworthy for other districts in which the peculiarities are different. Mr. Rawlinson, the eminent drainage engineer, gives sage counsel to the engineers devising drainage works, and recommends them to become acquainted with the established principles of hydraulics rather than depend upon published tables of size and strength of drains and sewers. In commencing to drain a town district, the first questions the engineer should ask himself are—"How have surface waters passed off up to this time without the aid of sewers or drains? Have any surface impediments been formed? if so, what are the effects, and can such impediments be removed? Have houses been erected and cellars excavated in improper places, and where injurious flooding cannot be prevented excepting at a ruinous cost to the rated property of the district generally? Can water-courses in the valley-lines be deepened at a moderate cost? Can embanking and pumping be resorted to economically? Are there any mill and mill-dams which impede drainage and cause injurious subsoil-flooding regularly, and injurious flooding at intervals? All these questions have a most important bearing on the dimensions of sewers."

11. The following suggestions as to the carrying out of drainage schemes are given by Mr. Rawlinson, in his paper read before the Society of Arts, March 29, 1862:—

> "Natural streams down valley-lines should never be converted into sewers. The maximum flow of water in such streams is to the minimum as 300 or 400 to 1. Any sewer formed in such valley-line of sufficient capacity to carry off flood-waters, would be much larger than requisite for the ordinary flow, and would become a cause of nuisance in dry weather. All valley-lines should be improved, and the beds of natural streams should be preserved free and open for the escape of surface and foul water. Sewers and drains should be of sufficient capacity to remove roof, yard, street soil, subsoil, and slop-water from the area, drained during ordinary weather, and should be graduated to the amount of work to be done. Flood-water outlets, or overflows into valley-lines, or natural streams to relieve the sewers during rains, should be provided. There may be large gratings to remove surface storm waters at the outlet points of valley-lines, but care must be taken not to make such places large stagnant cesspits.
>
> "All sewers and drains should be properly ventilated. This may be effected by connecting down-spouts with house drains in proper situations, by connecting sewers with tall chimneys, or by providing on the sewers and drains ventilating-shafts, with charcoal filters, for oxidising sewer gases. All sewers should have means of inspection, flushing and cleansing provided. Sewers should be laid in straight lines, and with regular gradients. At each alternate change in direction, or alteration of gradient, a manhole, or entrance to the sewer, should be constructed. Agricultural drain-tiles are laid in straight lines. Ploughing, on the most approved plan, is also in straight lines. In both cases truth and efficiency of workmanship are attained, and straight sewers and drains insure good workmanship. One defective link breaks the chain; one defective pipe-joint or defective yard of sewer is injurious.
>
> "Brick sewers should be formed of radiated bricks, set in hydraulic mortar. Pipes should be jointed with clay puddle, or with cement or mortar, or asphalte, according to the nature of the ground in which the pipes are laid. Great care should be taken in laying pipes in rock, in gravel, and also in clay. Many lines of sewer pipes are injured by injudicious filling of a trench, or by a fall of clay or earth crushing the pipes. The inlets of all drains should be properly protected, and the openings should be reduced so that any substance entering the drain may pass freely into the main sewer.

"Where a sewer or drain has once choked, and the ground is opened out for repairs, do not close it in again, but construct a manhole, or lamphole, that any future obstruction may be removed at once.

"Sewers and drains act as subsoil drains to the full length at which they are laid. In wet subsoils provision should be made for allowing subsoil water to enter the sewers. A continuous flow of subsoil water along a sewer or drain is generally an advantage, as the solids of sewage are more readily removed.

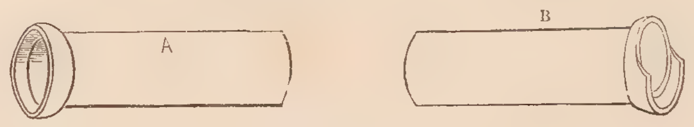
"Neither sewers nor drains should be laid under new inhabited dwellings. If it be absolutely necessary to carry a drain under a house, the drain should be carefully laid, and the joints made perfectly tight, so as to prevent the escape of sewer gases into the adjoining subsoil. Many lines of earthenware-pipe sewers and drains are ruined when laid in porous subsoils with leaking joints. The fluid sewage leaks away, and leaves the solids to accumulate, and ultimately to choke the sewer or drain as the case may be. Puddle should be used in such cases.

"All junctions with main sewers should be made at a point above the ordinary water-level in such sewers, and at the junction of branch or main sewers, the top of the sewers should be on the same level. Additional fall should be given at junctions or bends, to overcome increased friction.

"Junction entrances, provided for branch sewers and house drainage, should be protected by earthenware plates, or 'disc plugs.' Street gullies should be small, compact, and double trapped. There should be a sediment-box, easily removed and easily replaced. Means of flushing should be provided in the gully, that choking of the pipe connection with the sewer may be impossible. Large cesspit-gullies are a nuisance. Small gullies of cast-iron are generally found the cheapest and best; increase the number of small gullies rather than construct large cesspit-gullies.

"Fresh sewage, when properly diluted, filtered, or disinfected, may be passed into rivers or into the sea without causing a nuisance, or injury to fish. In arranging outlet sewers, provision should be made for applying the sewage to land in the immediate neighbourhood for agricultural uses, by gravitation if practicable. Pumping by steam or other power is available. A town standing on ground having quick gradients requires special arrangements to break the rush of water down and of gases up. This can be done by breaking the line with a vertical fall, placing a flap over the mouth of the sewer, and ventilating at this point. The outlet ends of all sewers should be protected with a covering-flap, to prevent the wind blowing in and driving back sewage gases. A cast-iron pipe of comparatively small dimensions on any river outlet sewer, will pass the dry weather flow of sewage to and below the summer level of the rivers as not to be a nuisance.

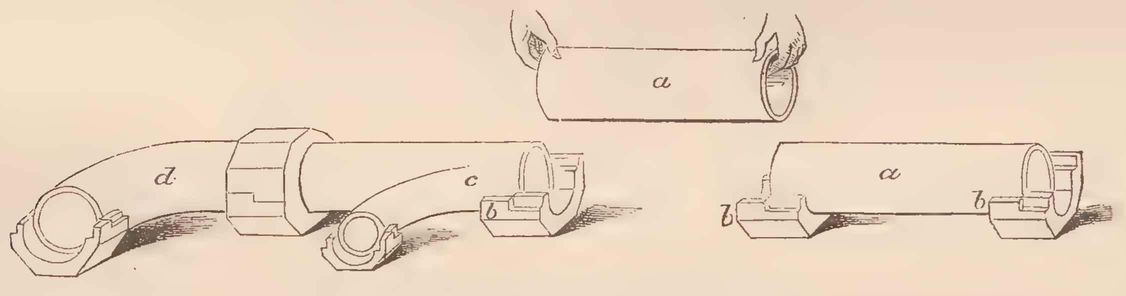
Fig. 6.



Forms of Circular Drain-tubes.

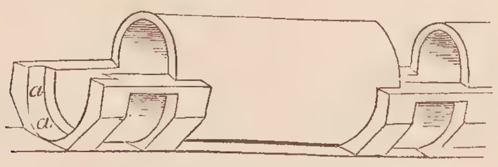
12. The constructive details of *house* drainage are very much simplified since the introduction of the earthenware tubes, or drain-pipes. An illustration of the form almost universally used is given in fig. 6, at A. By far the best material to make good the joints is well-puddled clay, well and carefully rammed up. We say carefully, for if the clay is allowed to spread itself beyond the joint into the interior of the tube or pipe, the flow of the sewage through it will certainly be impeded, and deposit will be made in it. The great objection to these common drain-tubes is, that in laying them in the trench they rest chiefly on their sockets, so that when the earth is laid over them, and the surface made good, the superincumbent weight breaks the tubes between the sockets. Again, in making the joints it is not very easy to see whether they are properly finished or not. Further, when pipes are laid for some time, and get silted up—as they frequently do, especially in cases where the "fall" is insufficient—it is a very difficult thing to ascertain the point at which the obstruction is without disturbing a great length of the drain. All these objections have been endeavoured to be met in a variety of ways. In fig. 6, at B, Pilbrow's rebated socket-ended pipe is shown, as manufactured by Stephen Green & Co. of Lambeth. By this arrangement the joint is obtained free from obstruction, and any single length of pipe is easily removed for repair, or otherwise, without disturbing the remainder of the length. But in this form the objection is still in force which we have made against the ordinary socket-tube as at A in fig. 6, namely, the resting on the sockets, and allowing the pressure of the earth to be upon the tubes between the sockets. This objection, and all the others above noted, are met in great measure by Cooper's (Wooten, Isle of Wight) drain-tubes, illustrated in fig. 7, where the tubes *a* are made in short lengths, and rest in chairs or saddles *b b*. Possibly the form of chair patented by Mr. Jenning (Holland Street, Blackfriars, London), is the better one. This, as shown at *a a*, fig. 8, is rebated. This admits of the better laying of the cement, or lute, and a more perfect joint is secured.

Fig. 7.



Cooper's Drain-tubes, Chairs, and Junctions.

Fig. 8.



Jenning's Drain-tube Chair.

13. In making junctions, these should not be at right angles, as at fig. 9 or fig. 10, but should be curved, as at *c* or *d*, in fig. 7.

Fig. 9.

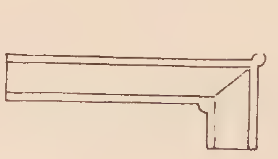
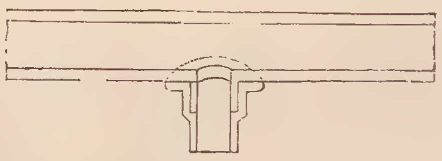


Fig. 10.

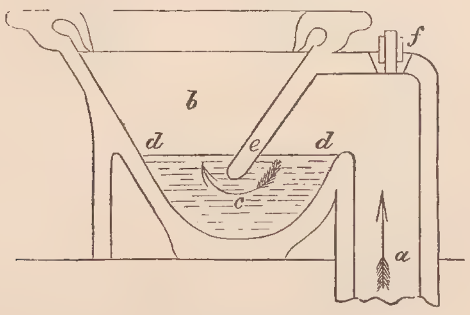


Defective forms of Junction.

14. To prevent the passage of the noxious air from the drains and sewers into the interior of the house through the medium of the water-closet, sinks, &c., &c., contrivances, termed "traps," are used. One of these, as applied to the earthenware water-closet, recommended by the Board of Health, is shown in fig. 11; in this any foul air passing up from the drain in the direction of the arrow *a* cannot get to the part *b*, in the direction of the dotted arrow *c*, and from thence into the house, inasmuch as the water *d d* is interposed to prevent it. Traps on this principle are, however, as demonstrated by Dr. Arnott, not by any means to be relied on. Traps are therefore now introduced with separate valves, in addition to the water-seal, at the point *c* of the mid-feather or

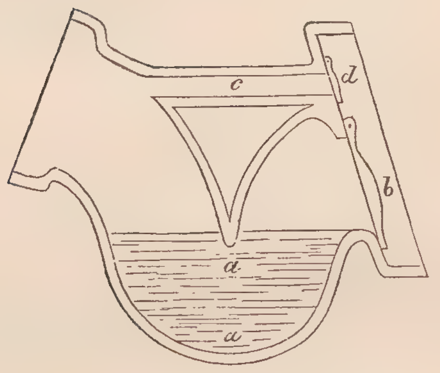
part *e*, fig. 11. Fig. 12 illustrates Lovegrove's patent trap, as manufactured by Mr. Jennings; this combines the usual form of water-trap *a a* with a valve *b*. This valve is placed at an angle, so that it always remains shut when the sewage is not passing through it; it is made of gun-metal, which does not corrode, and the surfaces are accurately ground. A subsidiary passage *c*, and valve *d*, admits of the passage of air through the drains to ventilate them, and aids the flow of the sewage.

Fig. 11.



Water-closet Pan Trap.

Fig. 12.

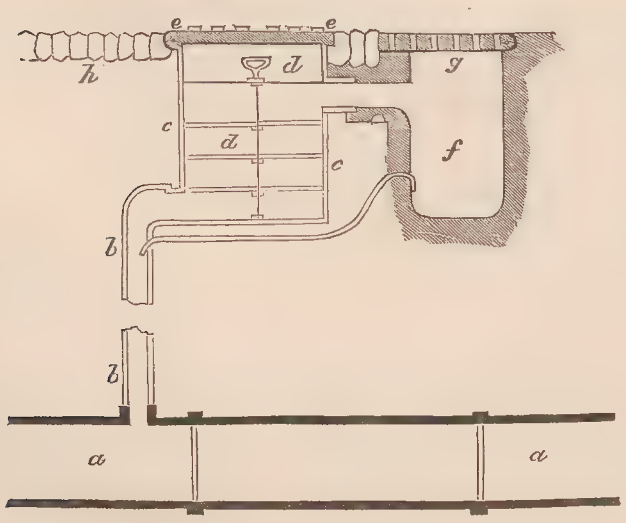


Lovegrove's Patent Trap.

15. Notice has already been taken (see par. 11) of the method of getting rid of the noxious exhalations of drains by their systematic ventilation. In fig. 11, *f* shows a pipe which leads off the foul air from the drain *a* to the external atmosphere.

16. By far the most perfect and complete system of getting rid of the noxious vapour of drains is to lead them through a furnace, or fire. But as this is only possible in a limited number of cases, a more readily-adopted method is that known as the "charcoal ventilator." This owes its introduction to the able advocacy of Dr. Stenhouse of London, who showed the efficiency of charcoal as a deodorizing agent. In the "Builder" of January 1, 1859, a claim is made for a prior introduction of this system by Mr. William Crozier, Borough Engineer of Sunderland, who states that so early as 1853 he carried out the scheme of which fig. 13 is an illustration—(for this we are indebted to the pages of the ably-conducted periodical above alluded to)—after consultation with certain eminent chemists. In fig. 13 *a a* is the main sewer; *b b* the pipe leading to the case *c c*, in which shelves of basket-work, *d d*, are placed, on these the pulverized, or broken charcoal, is placed; *e* the metal lid to the case; *f* the debris gulley trap, with grating at the street *g*; *h* shows the surface of the street.

Fig. 13.



Crozier's system of Ventilating Drains.

17. *Draining, as applicable to rural districts*, has been defined by an able authority to be "the art of rendering land not only so free of moisture as that no superfluous water shall permanently remain *upon* it, but that none shall remain so long *in* it, as to injure or even retard the healthy growth of the plants cultivated upon it for the use of man and the domesticated animals." The great distinction between town drainage and rural drainage is, that the drains or ducts for the former shall be *impermeable*, those for the latter *permeable*. The object of town drainage is to convey the sewage, say from one point *a*, indicating the house or place in which it is formed, to the point *b*, fig. 14, at which is the outlet to the main sewer *c*; the essential feature in the construction of the drain *d* being that it shall be so water-tight, or *impermeable*, that none of the sewage shall be permitted to pass from its interior and percolate through the surrounding soil *e e*. While the object of rural drainage is to convey the water ultimately to the point of outlet at the main drain or ditch *a*, fig. 15, by means of the drain or duct *b b*, still its further object is to permit the water from the surrounding soil *c c* to percolate through it, till it reaches the drain *b b*, by which it is conducted to the main outlet *a*. A drain then, in this instance, requires to be so impermeable as to lead such water as *enters* it, as quickly as possible to the point of outlet *a*, and yet so *permeable* as to admit of its taking up into its interior all water percolating through the soil, as in the direction of the dotted lines *c c*.

Fig. 14.

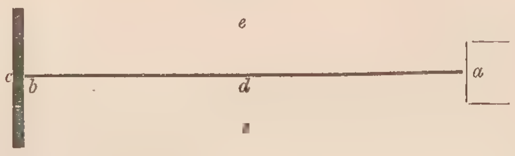
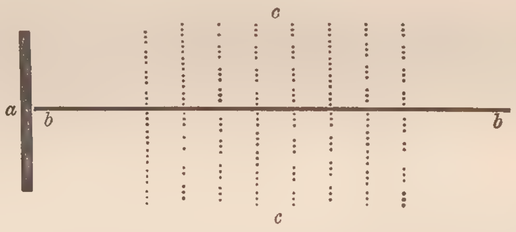


Fig. 15.



18. It is quite impossible within the limits of the present brief Essay to go fully into the details of rural drainage, a subject so wide and comprehensive as to require a volume to do it full justice, nor is this demanded of us; all that is required being an outline of the general principles which dictate the practice of drainage, and some observations mainly with a view to show their applicability to the drainage of building sites.

19. Soils for the purposes of the drainer may be classed under three divisions,—the (1) *Compact*, comprising tenacious, friable, and free or soft clays; (2) *Medium*, comprising clayey, gravelly, and friable loams; (3) *Porous*, comprising light and sandy loams, and light gravelly and coarse gravelly sands. The "tenacious clay" and the "coarse gravelly sand" may be taken respectively as the representative of the most difficult and the most easy land to be drained; between these two extremes an infinite variety of soils is met with, bringing into operation different modifications of depth and distances of drains.

20. In considering the subject, we shall divide our remarks into separate sections, as, *first*, the arrangement of the drains in the field or plot to be drained; *second*, depths of the drains

and the distances between them; *third*, the mode of executing the drains; and *fourth*, the cost of drainage in different soils.

21. *The arrangement of the drains in the field or plot to be drained.* The drains are of three kinds, the "main drains," "sub-mains," and the "minor drains." The main drains have for their object the conveyance of the water led into it through the medium of the small drains. The rule is to have in all cases the main drain laid along the principal hollow or the lowest part of the field; where there are other lesser or secondary hollows, sub-mains are to be placed all along these. Where the small drains are of such a length as to give them more water than they are calculated quickly to carry, sub-mains should be made into which the small drains should deliver, these sub-mains again communicating with the main drains. Where the slope of a field is all in one direction, as from *a* to *b* in plan, fig. 16, and *e* to *f* in section, fig. 17, the main drain is to be placed at the lowest part of the field, as at *c c*, fig. 16, and *g*, fig. 17; the small drains *d d*, fig. 16, running into it *at right angles*, and placed *parallel to each other.* Where the declivity or slope of the field is so pronounced as in fig. 17, the water from the small drains *d d*, fig. 16, is easily passed into it; but should the declivity or slope of the field be very little, the main drain is recommended to be made at a lower level than the outlet of the small drains which run into it. Thus let *a*, fig. 18, be the outlet or lower part of the small drain, *b* is the main drain, which should be at a depth of 6 inches below the outlet of *a*. The main drains of fields should not be placed near trees, the roots of which may penetrate into their interior and cause obstruction to the flow of water. For this reason, open ditches at the sides of fences should not be used as main drains; but the main drain should be cut out of the solid ground at a distance from the inner edge of ditch of 2 to 3 yards. The wide open ditches which formerly received the surface water of the fields being no longer required for this purpose, should, as Mr. Stephens recommends, be converted into a small drain, and covered up with soil, thus giving so much more land to the headland along which it runs. The position of the main drains being at the lowest part of the fields, there is of necessity a less slope or fall throughout their length than would be the case if they were placed differently; but in all cases sufficient fall must be given to it to enable the water to be carried rapidly away. Very little fall comparatively will be required for this, less indeed than is generally considered necessary. On this point Mr. Smith of Deanston has the following note:—"People frequently complain that they cannot find a sufficient fall, or *level* as they sometimes term it, to carry off the water from their drains. There are few situations where a sufficient fall cannot be found if due pains are exercised. It has been found in practice that a water-course 30 feet wide and 6 feet deep, giving a transverse sectional area of 180 square feet, will discharge 300 cubic yards of water per minute, and will flow at the rate of 1 mile per hour, with a fall of no more than 6 *inches per mile.* As before stated, main drains and sub-mains will be required in all the hollows. In the diagram in fig. 19, let *a m b* represent the main drain, into which a sub-main *c d* is led; this sub-main taking off the contents of the drains, draining the plot *g* which slopes from the ridge or highest part of it *e f* towards the sub-main *c d*; the other half of the plot *h* being drained by the drains *h*, leading from the ridge *e f* to the main drain *m a*. The plot or part *i i* slopes from *k k* to the line *l l*, at which is a second sub-main *l l* leading into the main *a b* at the point *m*. The field *n n* slopes from *o o* to the main drain *a m b*. The direction in which the small drains should run is one of the disputed points of drainage, two modes being recommended by different authorities. The mode generally practised, and that recommended by Smith, the great authority on deep draining, is to run the small drains in the line of the greatest fall or down the steepest descent, as from *a* to *b*, fig. 16, or *e* to *f*, fig. 17, the reasons for which are thus stated:—"Drains drawn across a steep cut the strata or layers of subsoil transversely, and as the *stratification generally* lies in sheets at an angle to the surface, the water passing in or between the strata immediately below the bottom of one drain nearly comes to the surface before reaching the next lower drain; but as water seeks the lowest level in all directions, if the strata be cut longitudinally by a drain directed down the steeps, the bottom of which cuts each stratum to the same distance from the surface, the water will flow into the drain at the intersecting point of each sheet or layer, on a level with the bottom of the drain, leaving one uniform depth of dry soil." The other mode recommended for placing the small drains is across the line of fall, as *e e*, fig. 16. Mr. George Stephens, the author of a treatise on Drainage and Irrigation, advocates this plan. Thus "a drain made across the slope or declivity of a field, or any piece of land, will undoubtedly intercept more water than when it is carried straight up the bank or rising ground; this principle holds good in every case, whether the drain be made to receive surface or subterraneous water. Drains winding across the slope or declivity of a field, whatever their number or depth may be, their effect upon tenacious or impervious substrata will be much greater than if they were made straight up and down the slope; and when the soil is mixed with thin strata of fine sand, which is the case nine times out of ten, the effect will be increased in proportion, and accordingly a much less number will answer the purpose." It may be stated, however, in reference to these points, that however correct in theory the mode may be of placing drains *transversely* to the line of the steepest descent, practice has decided the point in favour of running the drains *down* the steepest descent. By observing this rule, it aids one of the properties of water which makes it to seek the lowest level in all directions; and the water has the shortest way to percolate in its progress to the small

Fig. 16.

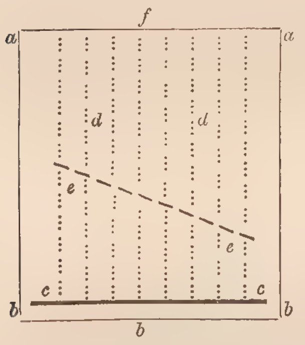


Fig. 17

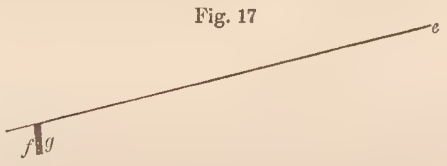


Fig. 18.

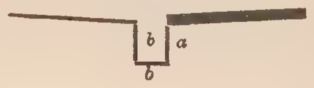
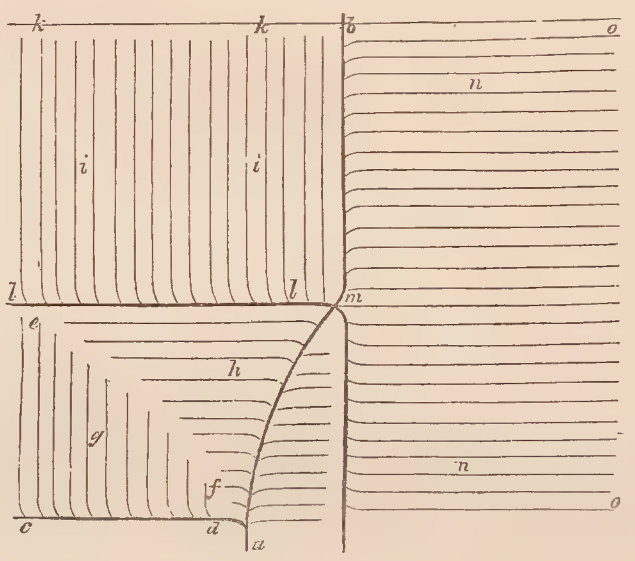
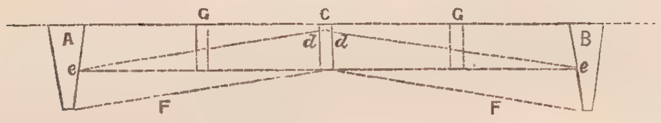


Fig 19.



drains, and once in their interior, it is obvious that it will be conveyed in the most rapid manner possible to the main drains. The extent of the drainage required for any particular plot of land may be ascertained by digging proof-pits or test-holes. These may vary in depth from 5 to 7 feet, and should be of diameter sufficient to enable a man to work freely in them. In place of these trial-pits, deep cuttings may be made in the field from one end to another; these should be in the same direction as the intended drains, so that they will at once serve the purpose of test-holes and beds for drains. On this point of test-holes, Mr. Andrew, the agricultural engineer, has the following:—"Before deciding upon the depth at which drains should be made, it is necessary to dig holes pretty close together, at right angles to an open cut which is to contain the main drain, then ascertain at what height the water stands in each hole. A section will thus be obtained, shown in the diagram in fig. 20, which will exhibit what is called the drawing powers of the drain, but which really shows the amount of resistance the soil opposes to the descent of the water. A and B are two drains, C is the centre hole midway between these cuts, and the line *d e* shows the draught of the drains A B; if it is decided that the water should stand at 30 inches in the centre hole, then it is evident that the drains A and B must be deepened to the dotted line F, or else the drains must be cut at the same depth and closer together as at C C. This principle must guide the judgment entirely in laying the drains as to depth or nearness, for the sectional lines *e d* and F F will always be obtainable in whatever description of soil is being drained, on however large a scale it is applied." With reference to the utility of test-holes, however, Mr. Bailey Denton—who has had a most extensive practice as a drainer of lands—states that they are only applicable in free soils, and that they afford no index in the drainage of clays. He says that he has attempted to drain clay lands by test-holes, but that so minute are the necessary observations requisite to enable safe deductions to be drawn, that the attempt has proved a practical failure. Not so, Mr. Denton remarks, in free soils, for the "deeper the drain, the greater and more certain will be the effect on the test-holes, and the judgment of the foreman is required to put into free soils as few drains as possible to effect the object aimed at, which is the response of the water in the test-holes to the influence of the drains. It is true skill to do what is required in the free soils, while care and judgment alone are requisite in the clay, the fact being that money governs the drainage of clay, judgment the drainage of free soil. You cannot drain clay lands too much, the greater the number of drains put into clays the better is the drainage, but money steps in and says, 'thus far go, and no further,' it will not pay to put in drains beyond a certain number, and there you stop." In short, expense seems to indicate that the rules applicable to the drainage of free soils are not applicable to the drainage of clays. The intermediate test-holes are the indices of perfection of the work of drainage in the free soils.

Fig. 20.



22. *The depth of the drains and the distances between them.*—The most important consideration in carrying out drainage works is the depth to which they should be cut. Let it be distinctly understood that a drain is not simply for the purpose of conveying away so much water from one part of a field to an outlet, but that its main object is to draw or lead off the water from the greatest possible cubical contents of the soil surrounding it. This, as the well-known drainage authority, Mr. Parkes, puts it, "is the true expression of the work done, as a mere statement of the cost of drainage per acre of surface conveys but an imperfect, indeed a very erroneous, idea of the substantive and useful expenditure on any particular system. This will be apparent in reference to the two last columns of the table, which give the cost in cubic yards and square yards of soil drained for one penny at the above-mentioned prices, depths, and distances.

Depth of the Drains in feet.	Distances between the Drains in feet.	Mass of soil drained per acre in cubic yards.	Mass of soil drained for 1d. in cubic yards.	Surface of soil drained for 1d. in square yards.
2	24	3,226½	4·1	6·27
3	33½	4,840	8·93	8·93
4	50	6,453	12·00	8·96

Much difference of opinion has long existed on the point as to the depth of drains; the experience of the last few years, especially in the drainage of the heavy tenacious clays, is altogether in favour of deep in order to secure thorough draining. It is better to err on the side of cutting the drains too deep than too shallow. Mr. Stephens, the author of the 'Book of the Farm,' places the minimum depth of drains in porous subsoils at 33 inches, in tilly subsoils 42, and in clay subsoils 50 inches. The discharging effect of clay and porous subsoils he places at the proportion of 18 to 1, that is, 1 inch of porous subsoil will part with the water contained in it or taken up by it as fast, indeed much faster, than 18 inches of clay subsoil.

At one period it was almost universally held, and is indeed yet by some still maintained, that it was of no use to drain clay lands deep, as the water could not percolate through the tenacious substance. This is now shown by a most extended experience to be altogether erroneous. The difficulty indeed would be to prevent water from percolating through clay to any depth of drain. We know of one instance where a most tenacious clay was drained to a depth of 4 feet 6 inches, and which every one said would be a failure, but which proved a most complete success. It is consonant with reason, says Mr. Stephens, "to give the greater depth to a drain in a subsoil that permeates slowly, whilst a smaller depth in one that permeates freely will be equally efficient. . . . The correct principle is to fix the minimum depth of the drain according to the nature of the subsoil, and make it as much deeper as circumstances will permit."

The distance between the drains is another point which is much disputed. It is obvious that the distances between the drains must be dependent on the depth to which they are cut. In many districts the distances between the old furrows have determined the distances between the drains. This practice is however founded upon no correct principle, for there is no direct connexion between the *old furrows*—or open drains, which in fact these furrows were—and the *new drains*. Everything will obviously depend upon circumstances of soil and locality. Mr. Stephens says, that in a partially impervious subsoil "three feet drains cannot be expected to dry more than 15 or 16 feet ridges, but that 4 feet ones will dry as effectually a distance not exceeding 24 feet. In porous subsoils 3 feet drains may dry 20 feet spaces with as great, if not greater, effect than these, and in deep hard loam, resting on impervious subsoil, . . . 4 feet drains will dry, I have no doubt, a distance of 30 feet." "I would feel," he continues, "exceedingly reluctant to recommend drains at more than 30 feet distance, unless the arrangement of the subsoil was peculiar, such as a porous subsoil of considerable depth, subdivided into beds by bands of clay, through the whole of which 4 or 5 feet drains at even double that distance might dry the soil. I have ventured to fix the minimum depth in carse clay at 50 inches, and as experience has not yet explicitly fixed their distance apart, I do not feel warranted in recommending a wider distance than 20 feet with that depth." ('A Manual of Practical Draining,' p. 67, Blackwood & Sons.) On the points now under discussion, the following evidence of various authorities as given in a Parliamentary Paper will be useful:—

"The depths and distances," says Mr. Smith of Deanston, "of drains that are in general use are very various, arising not only from the proper difference necessary to suit the different nature of the soils, but also from the difference in the opinions of engineers and practical farmers. The soils being so varied in character, no settled rule can be laid down. The depths in use, since the introduction of thorough draining, have varied from 2 to 3 feet, and, in occasional instances, 4 or 5 feet has been found preferable. The distances have ranged from 10 to 30 feet whilst in some cases, in peculiarly open subsoils, they have been extended to 40 feet with complete success. For a long time it was difficult to persuade practical men that depths beyond from 18 inches to 2 feet would be effectual in clay soils, at whatever distances they might be placed; but in the course of experience, the results of the examples set by those who adopted depths of from 2½ to 3 feet have led to the general adoption of such depths for all clays or compacted drift soils. Where beds of gravel, sand, or other open strata, occur within 4 or 5 feet of the surface, it is proper and usual to cut down to those beds when the outfall will allow, but these depths are seldom adopted except under such circumstances. Within the last four years, depths varying from 4 to 6 feet, with distances of from 36 to 60 feet, have been advocated by some engineers under general circumstances, and several practical men have adopted the system to some extent, on clay banks, in some instances, as they state, with satisfactory results; but in all such cases as have come under my observation, the results have not warranted the appellation of '*thorough draining*' when brought to the test of comparison with land drained at depths of from 30 inches to 3 feet, and with distances varying from 18 to 24 feet. Much of the soil that I have met with in the upland country of England, Scotland, and Ireland, of the drifted formation, is so difficult to cut at the greater depths, that the expense becomes too great to warrant its adoption, unless under very obvious advantages; and it is yet an unascertained point how far it is beneficial to remove the free water to a greater depth from the surface than from 2½ to 3 feet. The advocates of the deeper system, so far as I have been able to observe, seem to be returning in practice to depths not exceeding 4 feet, and to distances varying from 24 to 30 feet.

"Setting aside the moot question as to the proper depth at which free water should be retained, I do not so much object to greater depths than 3 feet, as I do to greater distances in *all* soils, as I have invariably found from experience that when distances beyond 24 or 30 feet have been adopted in *compact* soils, there has not been a perfectly, uniformly dry condition of the soil, especially when rain had recently fallen; so that if expense is to be saved by greater distances, I would prefer incurring the expense to the diminution, in any shade or degree, of complete and quick drainage. The experience of a succession of seasons is necessary fully to test drainage; and the extent of deep and distant drainage which has of late years been executed, will afford sufficient examples to test the practice in a cycle of seasons.

"The circumstance which has the most influence in ruling the distances of drains, and through these in some degree the depths, is the arrangement of the existing ridges. The width of the ridges runs generally from 12 to 24 feet, most commonly 18 feet; and as the ridges are usually thrown up in the middle from 12 to 18 inches above the levels of the furrows, a great saving in the cutting is effected by placing the drain in the line of the furrow; and besides, when the ridges are much raised, there is a tendency of the surface water to run towards the old furrow, even after the land has been drained; and if there is not a drain below or near to the furrow, there is an undue collection of water, which obtains for some years after the drainage has been executed, and until the ridges have been levelled down and the subsoil fully opened. The loss by this wetness or damp, or incompleteness of thorough and uniform dryness, is greater than the cost of having the drains somewhat less distant. There is also some difficulty practically in getting the drains cut to uniform depths when the surface in the lines of the drains is of various altitudes from the datum level of the bottom of the drains. Practically, therefore, it is found to be a much more ready method, and upon the whole cheaper and much more immediately fully effective, to adopt the furrows for the lines of the drains. In some cases, when the ridges are under 12 feet in width, I have found it expedient to place a drain in every second furrow only; and in cases where an inequality in the width of the ridges existed, I have found it proper to adopt those unequal distances for the drains. Where such distances have been adopted generally, it has been found that depths of from 2½ to 3 feet have, on all soils and at all times, produced a thoroughly dry condition of the soil.

"In Ireland, where the lazybed system of cultivation is followed, the practice is to place the drains in each alternate trench, which makes the distances about 18 or 20 feet, and the depths adopted vary from 2½ to 4 feet. As stones are plentiful, and labour cheap, the channels of the drains are generally formed of stones. Tiles and tubes are now being introduced, and these will no doubt be extended in use.

"In bogs and marshy land the drains require to be made the deepest, because from the nature of the structure of such land there is generally much bottom water to be removed, and the soil of bogs and marshes contracts and subsides much after being drained.

"In the floating bogs very much deeper drains are required; and where outfalls can be had, the depths of the drains should be as great as to remove, if possible, the whole of the bottom water, which can generally be done with a few deep drains, and the removal of the surface water can therefore be effected by frequent parallel drains of the ordinary depths and distances."

"The depths and distances of drains," says Mr. Macaw, "are various in relation to the different descriptions of soils.

"1st. On a thin clay soil and subsoil of great tenacity, drains were formerly 12 to 15 feet apart, and 2 feet deep. That depth increased to 2½ and 3 feet. Since the Drainage Act came into operation, the distance apart of drains was extended to 21 and 24 feet; the depth to 3½ and 4 feet. Soon after, however, the distance apart was contracted to 16 and 21 feet, the depth remaining the same; and this system now prevails generally on soils of the description named.

"2d. On a clay soil of less tenacity, having more sand or gravel in its composition, drains are now generally made from 3½ to 4 feet deep, and 21 to 27 feet apart.

"3d. On soils of greater porosity, with less clay in their composition, and where spring water exists, drains are being made from 4 to 5 feet deep, and from 27 to 40 feet apart.

"The main drains are generally cut a few inches deeper than the branch drains.

"In some cases, rock, lying near to the surface, interferes. Where this occurs, drains are put in at more contracted distances apart, and, if practicable, the rock is cut—at least through its loose surface, to form the bed of whatever material is used as a conduit, and the lines of drainage are then wrought out at a uniform depth or distance apart.

"In drainage of moss-lands, where the drains cannot be cut through the moss, they are now generally cut to 5 feet deep and from 18 to 24 feet apart; but when the moss can be cut through about this depth, the distance apart of drains is very much extended, depending on the nature of the subsoil, from, say 24 to 36 feet. Where this can be obtained it is very effective.

"Moss, of a very wet and soft character, cannot be properly drained in one season, particularly when of great depth. This description of moss generally occupies a very level position, and the inclination for the proper discharge of the water must be wrought out in the drains. After drainage it subsides more at its centre—or where its deepest body exists—than at its edges; consequently, the drains at those deep parts become depressed beneath their first levels, and often below that of their outlet, and hence the propriety of keeping the drains open during the first season at as great a depth as practicable. By cutting their sides perpendicular they are found to stand better than by sloping them. In the second season they are cut out and finished."

Mr. Beattie says—"The depth of drains in agricultural lands are seldom made less than 3 feet. On the rich clayish lands 3½ and 4 feet. On marshy or mossy soils from 4 feet to 6 feet and upwards, as circumstances may admit.

"Every description of soil subsides after being thoroughly drained. Marsh lands, in some instances, will subside 1 or 2 feet. Ample allowance should be made in the depth of the outfalls and the drains for this subsidence.

"Thorough drainage, under the influence of the Inclosure Commissioners, has now become nearly an universal system, and most engineers agree that the deeper drainage at moderate distances apart is most effectual and permanent."

Mr. Scott says—"Drains are generally 3 to 5 feet deep and from 20 to 50 feet apart; in strong, retentive, pure clays, from 3 to 4 feet deep, placed at distances of from 20 to 36 feet apart; in porous subsoils, such as gravel, or sand, 4 to 5 feet deep, and 40 to 50 feet apart. In some cases the drains are made deeper and placed further apart.

"A great difference of opinion exists in different localities as to depth and distance of drains. It frequently occurs from prejudice, influenced by the custom that has prevailed in each district. There is a difference of opinion on this point by draining-engineers, but the prevailing opinion is in favour of deep drainage."

23. *The execution and formation of the drains.*—An essential point to be observed in the execution of drainage is the uniformity of the slope or level of the bottom of the trenches. The method of accomplishing the perfectly-uniform slope of the drains, from their highest point to the outfall, is by the use of the "boring-rods," or by the "spirit-level." In the boring-rod system "three staffs are made use of, two of them 2 feet long, and the third as much more than 2 feet as the drain is deep—that is, if the drain is 3 feet 6 inches deep, the staff must be 5 feet 6 inches long. The staffs are strips of wood, with cross-pieces, 9 inches long at the end that is to stand uppermost. The two shorter staffs are planted upright, one on the ground on a level with the field at the head of the drain, and the other at the lower end, and a person stands at one of them looking over its top, with his eye on a line with the other. A second man then takes the longest staff and holds it upright in the drain, just touching the bottom, and walks along from one end of the drain to the other, keeping it in the upright position. If, while it is moved along, its top always appears in a line with the tops of the other two—as seen by the person looking along the three—the fall of the drain is uniform; but if it rises above this line at any one place, the bottom is too high there, and requires to be reduced; if it falls below the line, the bottom is too low, and must be raised. In this way the fall may be rendered perfectly uniform."

In cutting the drains the best way is to commence with the main drain, and at its lowest point, working gradually up to its highest. To test the depth of the drain, in place of using the measuring-tape, a gauge should be used. This consists of a vertical rod, divided into feet and inches, with cross arms, which can be moved up and down the rod. These cross-arms should be as long as the width of the drain at certain points—at the bottom, middle, and top—so that when the gauge is put into the drain, all the arms touch the sides of the drains, showing that its taper is correct. As soon as the main drain is cut, the distances of the small drains which lead into it should be marked off, and the level of the bottom of these drains should, as before stated, be 6 inches above the level of the bottom of the main drain. Each length of drain should be cut from end to end before they are filled up with the drains. A small drain should be placed at *a a*, fig. 17, at the head of the drains *a b*, *a b*, connecting the whole so as to drain the head-land *f*. For draining hill sides and for surface-drains, the simple forms, as shown in figs. 21 and 22, are used, being merely channels for taking off the surface-water. These, of course, exercise no influence on the subsoil.

Fig. 21.

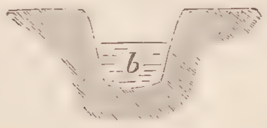
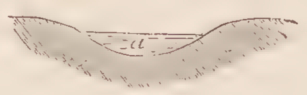
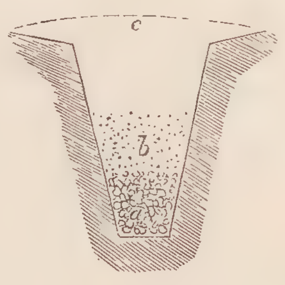


Fig. 22.



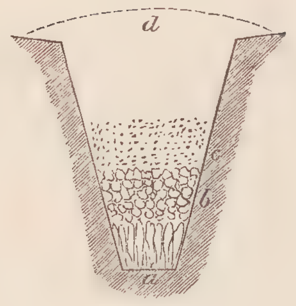
Surface or Furrow Drains.

Fig. 23.



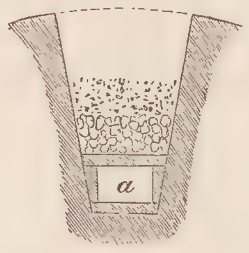
Stone-filled Drain.

Fig. 24.



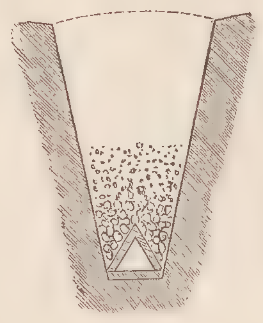
Stone-filled Drain.

Fig. 25.



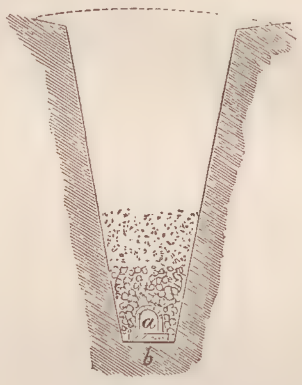
Rectangular Stone Drain.

Fig. 26.



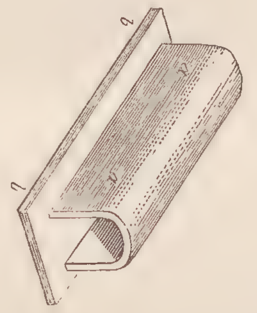
Angular Stone Drain.

Fig. 27.



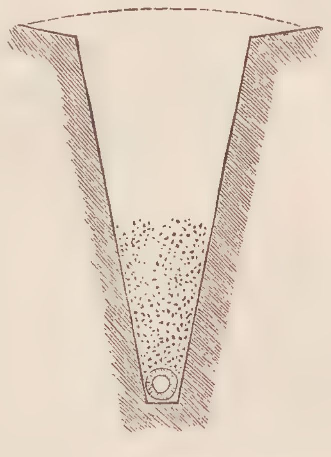
Tile and Sole Drain.

Fig. 28.



Tile and Sole.

Fig. 29.



Tube or Pipe Drain.

The filling of the drains is done in several ways, as illustrated in figs. 23 to 28. Where stones are easily obtained, the drains may be filled as shown in fig. 23 or fig. 24. Where flat stones can be obtained, the mode of filling in the drain as in fig. 25 or in fig. 26 may be adopted. Fig. 27 shows the mode of filling in the drain with the horse-shoe tile and sole. Fig. 28 shows the mode of putting the tile and sole together. But by far the best mode, and that which is now universally adopted, for filling in the drains, is by the use of the drain-tube as illustrated in fig. 29. The tubes are often simply placed end to end, without any means of connecting them, but the improved mode is to pass a collar over the junction. This serves the double purpose of keeping the tubes together and preventing the entrance of roots, which have a tendency to choke up the drains. In filling up the drains either with stones, tiles, or with tubes, the whole drain or trench should be cut from end to end before any of the materials are put in. The practice is a wrong one which fills in the drains as they are cut, for it is impossible when this is done to test the fall of the drain. Again, some commence to fill up the drains beginning at the low and working up to their high level; it is obvious, however, that the best way is to commence filling in from the high down to the lowest point, as all the material taken out in finishing off can be worked easily down in the direction of the fall. The entrance or outfall of the main drain should be protected with a self-closing flap or valve, especially where the outfall is into a tidal river. By means of this contrivance back-water or vermin can be prevented from entering, while all freedom is given to the flow of the water from the main drain. Figs. 15 and 37, plate XXXI., shows a form of valve manufactured by James Burton, Engineer, John's Place, Holland Street, Southwark, London.

24. *Cost of Draining operations.*

"The principal circumstances," says Mr. Spooner, "which determine the cost of drainage works are—the labour of cutting and filling the drains, the material of which the drain itself is formed, and the outlets for the discharge of water. Of these the last increases in proportion as the ground is steep and irregular, or unusually flat, and can only be included in a general estimate where the surface gently undulates; the material also varies greatly in cost, arising in the case of tiles in the supply being near at hand and equal to the demand or otherwise, and in the case of stones in the distance of carriage.

"It was formerly considered that the cost of drainage was equally divided between that of the labour and material; and in 2½ to 3 feet drains filled with stones or horse-shoe tiles, on soles, this is about the case; but the more general introduction of pipes, and the improved methods of making them, have occasioned a considerable balance in favour of material, while increase of depth has increased the cost of labour.

"This latter item can be determined with sufficient accuracy by referring it to a standard pretty generally known, viz., the value of moving a solid yard of earth of any one description of hardness; and to illustrate this, I have drawn up the following table, which supposes two sets of drains, the one opened for stones, the other for tiles, and at depths of 3 feet, and 3½ feet, and 4 feet respectively. I have shown the average width of the cutting for each size and sort, the number of lineal yards required to equal a solid yard in each; and assuming three descriptions of soil, the differences in hardness of which make the cost of moving their solid yard 4d., 6d., and 8d. respectively, I have calculated the labour value per yard and per rod linear of the different depths and sorts; and these will be found to tally very closely with the prices at which the work is done.

"It is a common remark that the cost of making drains is double by every foot of increased depth given, and the same in proportion for every part of such increase; the following table shows that this is so."

The first part of the table refers to drains filled with stones in the manner shown in fig. 24, and to three different sizes and depths of drains—first a drain 4 feet deep, 18 inches wide at upper part, second 3½ feet deep, 16 inches wide at top, and third 3 feet deep, 12 inches wide at upper part—the width of all these drains at bottom being the same, namely 8 inches. *The second part of the table* refers to drains filled in with drain tubes as in fig. 29, and to three sizes and depths—first 4 feet deep, 18 inches wide at top, second 3½ feet deep, 16 inches at top, third 4 feet deep, 12 inches wide at top—width at bottom of all the sizes the same, namely 3 inches.

STONE-FILLED DRAINS.

Depth of each Drain.	Average width of Drain.	Running yards of Drain to the cubic yard.	Sandy soils, light loams and light clays. Easy digging. At 4d. ⅌ cubic yard.		Stiffer Clay and Gravel, requiring some pick-work. At 6d. ⅌ cubic yard.		Hard Clay and close Soils, requiring pick-work before they can be done. At 8d. ⅌ cubic yard.	
	Inches.	Yards.	⅌ yard.	⅌ rod.	⅌ yard.	⅌ rod.	⅌ yard.	⅌ rod.
			d.	d.	d.	s. d.	d.	s. d.
4	14	2 +	2	11	3	1 4½	4	1 10
3½	12	2½ −	1⅗	9	2⅖	1 1¼	3⅕	1 5½
3	10	3½ +	1⅐	6¼	$1\frac{5}{7}$	0 8½	2½	1 0½
TUBE-FILLED DRAINS.								
4	10½	2½ +	1⅗	9	2⅖	1 1¼	3⅕	1 5½
3½	9½	3¼	$1\frac{3}{13}$	7	$1\frac{11}{13}$	0 10¼	$2\frac{6}{13}$	1 2
4	7½	$5\frac{1}{15}$	0¾	4¼	1⅕	0 6½	1½	0 8¼

The signs + and − attached to the figures in the third column imply a small fraction greater or less than the number stated. The cost per rod for labour being ascertained by the above table, it is easy to reckon up the number of rods and of tubes required per acre. The following table being that which is circulated by the Inclosures Commissioners, is recommended by Mr. Spooner as the best he has seen:—

Descriptions of Soils.	Distance of Drains apart in feet.	Depth of Drains. Feet and inches.	Number of yards of Drains per acre.	Cost of cutting & filling per chain (22 yards).	Cost of cutting and filling per acre.	Number of Drain *Pipes*, of 12 inches long, required per acre.	Cost of Drain *Tiles* per acre, at 30/ per 1000.	TOTAL COST per acre.
HEAVY SOILS.				s. d.	£ s. d.		£ s. d.	£ s. d.
Compact, tenacious, gravelly clay,	15	2 6	968	1 8	3 13 4	2,905	4 7 2	8 0 6
Stiff adhesive clay, ...	16½	2 6	880	1 7	3 3 4	2,640	3 19 2	7 2 6
Friable clay, ...	18	2 9	807	1 6	2 15 1½	2,420	3 12 7	6 7 8
Free soft clay, ...	21	2 9	692	1 4	2 2 0	2,076	3 2 3	5 4 3
MEDIUM SOILS.								
Clayey loam, ...	22	3 0	660	1 8	2 10 0	1,980	2 19 5	5 9 5
Marly loam, ...	24	3 0	605	1 6	2 1 3	1,814	2 14 5½	4 15 8
Gravelly loam, ...	27	3 3	538	2 4	2 17 2	1,613	2 8 4½	5 5 6½
Friable loam, ...	30	3 3	484	2 0	2 4 0	1,452	2 3 6½	4 7 6½
LIGHT SOILS.								
Light gravelly loam, . . .	33	3 6	440	2 10	2 16 8	1,320	1 19 7	4 16 3
Light marly loam, . . .	36	3 9	403	2 8	2 9 4	1,219	1 16 3	4 5 7
Sandy loam, ...	39	4 0	373	2 6	1 19 8	1,117	1 13 6	3 3 2
Soft light loam, ...	42	4 0	316	2 4	1 16 9	1,037	1 11 1½	3 7 10½
Sandy soil, ...	45	4 0	325	2 4	1 14 5	974	1 9 2½	3 3 7½
Light gravelly sand, . . .	49½	4 3	293	3 4	2 5 0	880	1 7 4½	3 12 10
Deep " " . . .	55	4 3	264	3 0	1 16 0	792	1 3 9	2 19 9
Coarse " " . . .	60	4 6	242	4 0	2 4 0	726	1 1 9	3 5 9
Loose " " . . .	66	4 6	220	3 4	1 13 4	660	0 19 9½	2 13 1½

25. *The Drainage of Building Sites.*—Much of what has been already given on the subject of drainage of rural districts has direct and immediate reference to the drainage of building sites. The cost, however, of the drainage of the sites is much greater than that of agricultural lands, in consequence of the more complete drainage required, and the increased depth of the cuttings necessary to clear the sites from all surplus water. It is somewhat remarkable how the importance of the drainage of building sites has been so completely overlooked, in presence of the obvious disadvantages arising from damp. All methods in use to prevent damp from rising in walls from the ground on which they rest are but palliatives; the true remedy or preventive is the getting rid of the water from the ground itself; this can only be done by thorough drainage of the site on which the building is to be placed. The drainage requires to be deep and close. In a Parliamentary paper, issued under the direction of the Board of Health, much valuable information is given on the subject of the drainage of building sites. A few of the estimates of the cost of executing drainage for different plots of land we give here. *Case 1st.* An acre of land with detached villa residence, the site of the buildings deep drained, and the rest of the ground thoroughly

drained (fig. 30). *Case 2d.* Half an acre of land laid out for two detached villa residences, the sites of the buildings deep drained, and the grounds thoroughly drained (fig. 31). *Case 3d.* One acre of land laid out for 12 semi-detached villa residences, and thoroughly drained (fig. 32). In all these diagrams ... represent the small drains, — the main drains, and ═ the road sewers or drains.

Fig. 30.

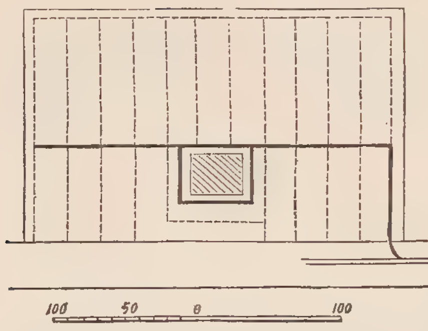


Diagram illustrating Drainage of one acre of Land for a Detached Villa.

Fig. 31.

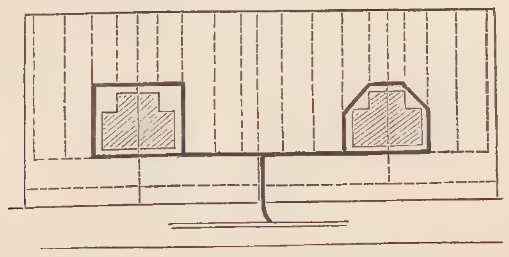


Diagram illustrating the Drainage of half an acre of Land for Two Detached Villas. Scale in fig. 30.

Fig 32.

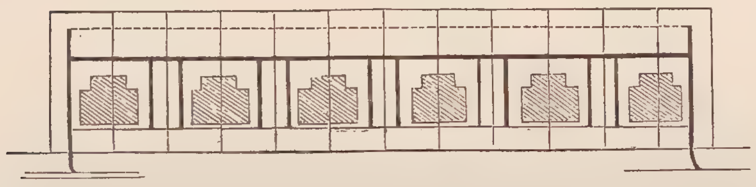


Diagram illustrating the Drainage of an acre of Land for Twelve Semi-detached Villas.

Labour and Material.	Quantities.	Light Soils.		Medium Soils.		Heavy Soils.	
		Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
		CASE 1ST.					
		d.	£ s. d.	d.	£ s. d.	£ s. d.	£ s. d.
Deep drains (5 feet), at ⅌ yard, ...	147	4	2 9 0	5	3 1 3	0 0 6	3 14 6
Drain pipes (1¼ inch diam.), at ⅌ 1000, .	441		0 14 5		0 15 5	1 15 0	0 15 5
Minor drains (3½ feet deep), at ⅌ yard, .	622	2½	6 9 7	3	7 15 6	0 0 4	10 7 4
Drain pipes (1 inch diam.), at ⅌ 1000, .	1,866		2 6 7		2 6 7	1 5 0	2 6 7
Total,			12 0 7		13 18 9		17 2 10
Annual charge as improvement rent or rate for 20 years, . .			0 18 3½		1 1 4¾		1 6 0¼
		CASE 2D.					
Deep drains, at ⅌ yard,	161	4	2 13 8	5	3 7 1	0 0 6	4 0 6
Drain pipes (1¼ in.), at ⅌ 1000, ...	483		0 16 10		0 16 10	1 15 0	0 16 10
Minor drains, at ⅌ yard,	242	2½	2 10 5	3	3 0 6	0 0 4	4 0 8
Drain pipes (1 in.), at ⅌ 1000, ...	726		0 18 1		0 18 1	1 5 0	0 18 1
Total,			6 19 0		8 2 6		9 16 1
Annual charge as improvement rent or rate for 20 years, . .			0 10 8		0 12 3¼		0 14 11½
Do. do. per house, ...			0 5 4		0 6 1½		0 7 6¾
		CASE 3D.					
Deep drains, at ⅌ yard,	484	4	8 1 4	5	10 1 9	0 0 6	12 2 0
Drain pipes, at ⅌ 1000,	1,452		2 10 9½		2 10 9½	1 15 0	2 10 9½
Minor drains, at ⅌ yard,	147	2½	1 10 7	3	1 16 9	0 0 4	2 9 0
Drain pipes, at ⅌ 1000,	441		0 11 0		0 11 0	1 5 0	0 11 0
Total,			12 13 9		15 0 3½		17 12 9½
Improvement rate, ...			0 19 4¼		1 2 10½		1 6 11
Do. do. per house, . . .			0 1 7½		0 1 11		0 2 3

To prevent the mud and detritus from the land main-drain passing into the sewer, or road drain, a road-side trap, as shown in fig. 25, Plate XXXI., should be used. In this *a a* is the cess-pit, in which the detritus is lodged, and into which the main land-drain delivers the drainage-water; *b* is the grating giving access to the surface-water of the road; and *c c* is the tube, or pipe, leading off the surplus water to the road drain, or sewer.

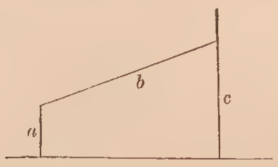
26. *Drainage of Roads—Suburban Water-courses and Ditches.*—The advantages of getting rid of the open ditches skirting the public and private roads of suburban and rural districts need scarcely be here detailed; two need only be here referred to—the diminution of surfaces of stagnant water, and the prevention of unwholesome evaporation. The Commissioners, in their Second Sanitary Report, recommended these open drains, or ditches, to be done away with, and tubular drains substituted for them. In fig. 22, Plate XXXI., we give a diagram illustrating the condition of roads with open ditches; *a a*, road; *b b*, side ditches; *c c*, the hedge, or fence, backing. In fig. 23, in the same Plate, a diagram is given showing the improved method of laying out roads with tubular drains. The tubular drain-pipe, as *e*, may be placed at the bottom of a vertical trench, *f f*, filled in with stones *c*, or the drain-tube *d* may communicate by means of a tube *c* with the trap *b*, which receives the surface-water of the road *a*. Fig. 25, Plate XXXI., shows a form of trap on a larger scale. In cases where the open ditches are liable to be flooded at one time and nearly empty at another, a very excellent plan has been adopted by Mr. Grant, one of the surveyors to the Metropolitan Commission of Sewers, in which a tubular drain is placed along the bottom of the ditch. When the supply of water is limited, in place of spreading itself out in thin, stagnant, and little pools in the bottom of the ditch, it is taken up and circulated in the tubular drain, as at *h*, fig. 24, Plate XXXI., the ditch *g g* being left quite dry. When the ditch *g′ g′* is flooded, both it and the tubular drain *h′* are filled. Fig. 21, Plate XXXI., shows the mode of constructing and draining roads in heavy soils, as designed by Mr. Bailley Denton, and described in the Journal of the Royal Agricultural Society of England. In this drainage of the road *a a a*, is secured by the open ditches *b b* and the tubular drains *f f*, placed under and at each side of the metalling *e e*. The width of road from *a* to *a* should be 18 feet, and the depth of ditches *b b* 18 inches at the least. The width of metalling *e e* should be 9 feet. The depth of the drains *f f* should be 4 feet from surface of road, their diameter being 2 inches. These 2-inch drain-tubes *f f* should be "connected with the culverts, or drains, crossing the road at every fence and every hollow in the ground; and these cross culverts, or drains, should be laid so low in connection with existing ditches (to be deepened, if necessary, for the purpose) that the crown of the cross culvert, or drain shall be no higher than the bottom of under drain." At the ends of each cross culvert there should be an iron grating to prevent the passage of vermin. The metalling should be 9 inches deep at least, and of uniform depth throughout its entire width, and convex in form on its upper surface. The foundation, or sub-stratum of the metalling, should be about 4½ inches in depth. The upper surface, or metalling, may be of clean stone, sifted gravel, or pebbles, and none of the portions should be larger than 2½ inches in the longest diagonal line. The surface of the road, when finished, should present the convex appearance of the diagram. Hedges, as *c*, should not be planted, as they overshadow the road and prevent its rapid drying. A fence of iron wire, with straining posts, as *d*, may be substituted. In fig. 26, Plate XXXI., we give the diagram of a road of causeway stones, *a a*, *b b*, the side path; *c* the drain or ditch for the surface-water; this is led from the side channel *e* by the drain-tube *d*.

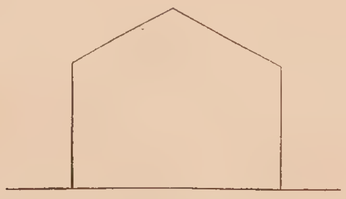
ON GARDEN STRUCTURES.

GREEN-HOUSES, CONSERVATORIES, VINERIES, PINERIES, AND PEACH-HOUSES.

1. In presenting to the reader a few notes on the subject of Garden Structures, their Arrangement and Construction, we purpose making them the vehicle for conveying information more of a practical than of an historical or descriptive character; the limited space at our disposal scarcely permits of doing full justice to the practical; it totally precludes the possibility of even attempting to do justice to the historical or descriptive points of the subject, interesting as these undoubtedly are. For information on these we cannot do better than refer the readers to the elaborate works, the "Book of the Garden," by Mr. C. M'Intosh (Blackwood & Sons, Edinburgh and London), and to the "Cyclopædia of Gardening," by Mr. Loudon (Longman & Co., London), both of which may be consulted with interest and profit. Garden structures may be divided into two classes, "Plant-houses," and "Forcing, or Hot-houses." The first are designed for the rearing of plants and flowers—as green-houses, conservatories; and the second for fruit—as grapes, pine-apples—and of vegetables—as cucumber and melon pits. We shall take up the consideration of Green-houses, Conservatories, Vineries, Pineries, and Peach-houses.

2. Green-houses.—The simplest form of garden structure for the rearing and preservation of plants and flowers is generally known as a green-house. It is generally of small dimensions, of simple and unpretending design, and is very frequently attached to the house; entering directly from it. In some cases it projects from a wall, and forms a "lean-to" thereto. They may, however, and in practice often do, form independent or isolated structures. Of the two forms the "lean-to," as the house *a b*, against the wall *c*, is considered by authorities to be the worst adapted to the healthy rearing and display of plants, and the isolated or independent structures, with the ordinary form of span-roof, by far the best. In connection with this point the following remarks of an eminent authority on Hot-house Construction may be read with advantage:—





"It is a well-known fact that plants that are grown in what are called lean-to green-houses, have exactly the character of the house in which they are grown, *i. e.*, they are one-sided; nor is it possible, without a vast amount of labour and attention on the part of the gardener, to grow them otherwise. In this respect the cultivator does not imitate nature, but rather the monstrosities of nature. Trees and shrubs only grow one-sided when their position precludes the access of light and air around them, but they grow naturally into a compact bush, which is universally allowed to be the most beautiful form that plants can assume.

"Even a handful of cut flowers have their beauty, and are generally admired; but when seen upon the living plant, whatever shape or form the latter may possess, how much greater their charms! If, therefore, we add to these natural beauties the additional charm of a positively beautiful form, surely it will double their claim to our admiration. And we may here add the gratifying fact, that this claim is now generally recognised by all who can appreciate the superior beauty of well-grown plants.

"The principles upon which plant structures ought to be built are somewhat different from those which regulate the erection of forcing-houses, culinary-houses, &c.; and as their purposes are different, their shape and forms are generally also different. Plant-houses admit of a greater variety of shape and design than any of the kinds previously mentioned, and as they are generally erected in private grounds for ornament and display, they should have a more artistic character than the others.

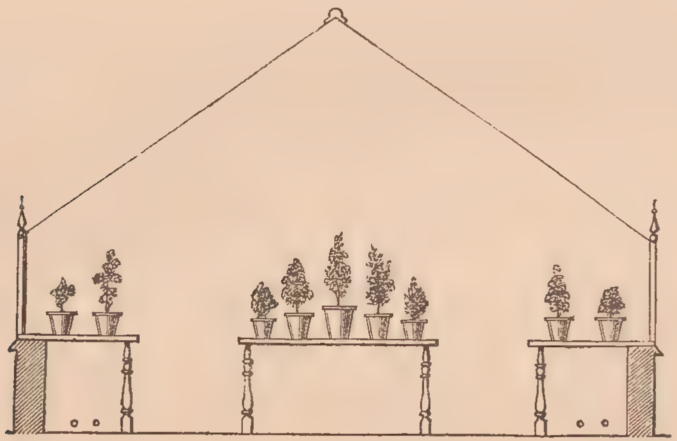
"The size of the green-house may vary according to the extent of the collection to be cultivated, but it should always have a length proportionate to its height and width. There is a great inconvenience in having the green-house very capacious; and where it is desirable to have a large collection of plants, it is best to have a conservatory for the growth of the larger specimens, or a stove for the palmaceous families of plants. We shall, however, allude to what is properly termed the green-house.

"A first-rate green-house should be completely transparent on all sides; lean-to houses are decidedly objectionable, for the reasons already given. Houses that are only glazed in front, and have glass-roofs, but otherwise opaque, are also objectionable, as plants can never be made to grow handsome. They become weakly and distorted by continually stretching towards the light, neither do they enjoy the genial rays of the morning and evening sun, and only perhaps for a few hours during mid-day. If such houses be large and lofty, they are still more unmanageable, as no culture can keep the plants symmetrical and of good appearance.

"A green-house should stand quite detached from all other buildings, and may be of any form the fancy may dictate or the position suggest. It may be circular, oval, hexagonal, octagonal, or a parallelogram, with circular or curved ends. The house, to be proportionate, should be about 50 feet in length by 20 in width, and 14 feet high above the level of its floor; if more effect be required from the external view, its parapets may be raised, to give the house a loftier appearance. The parapet should be not more than 2 feet high all round, the upright glass about 2½ or 3 feet more, including base, plate, and sash-bars. The house should be surrounded by a shelf 2 feet wide, level with the top of the parapet wall. This shelf is of great importance to a gardener, and is generally the best place for the finer kinds of plants, being surrounded on all sides with light, and, being near the glass, they grow bushy and dwarf in habit, in which state they are most pleasing and attractive. Next to this shelf comes the pathway, 3 feet wide at least, having just enough room between the roof for the tallest individual to clear the roof and rafters; then the stage, or centre tables of stone or timber, and arranged according to the size of the plants to be grown."

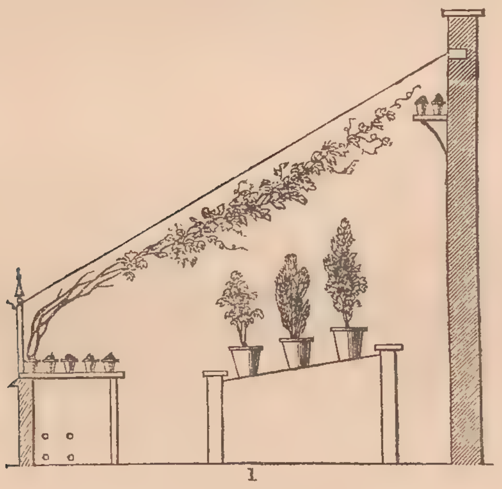
3. Fig. 1 shows in section the arrangement of a "span-roofed green-house, and fig. 2 one on the "lean-to" principle. These are both constructed on Dennis's patented principle, which will be found fully described in a future paragraph. On this point "span-roofed" as against "lean-to" *plant-houses*, the following opinion of Mr. M'Intosh is further worthy of special notice:—"The reader will at once see the necessity of abandoning the old and absurd practice of placing plant-houses against the face of solid walls, let the aspect of that wall be to what point it may. Hence it follows that all plant-houses should stand detached from all other buildings, and form of themselves entire and complete structures, having the sides and ends in all cases uniform." ("Book of the Garden," vol. i. p. 395.) In fig. 5, Plate XVII., we give front elevation, and in fig. 6 side ditto, of a span-roofed green-house, with curvilinear ribs or rafters, the section of which is shown in fig. 7a of the same Plate. This green-house has been erected by Messrs. Shanks & Son of Arbroath.

Fig. 1.



Section of Span-roofed Green-house.

Fig. 2.



Section of Lean-to Green-house.

4. In Plate XVII. we give a plan in fig. 1, and in fig. 2 an elevation of a green-house, with small hot-house attached. This is well adapted for the garden of a moderate-sized villa, but is quite large enough to maintain a good succession of flowering plants. The following is a descriptive specification of this structure.

5. "The total length outside the walls is 36 feet, the inside dimensions of the green-house being 20 feet long by 14 feet wide, and those of the hot-house 13 feet by 14 feet. The back wall is of 14-inch brickwork, the foundation being of 18-inch work up to the ground-level, 5 feet 6 inches deep, resting on a footing-course, and covered at the height of 13½ feet with a chamfered stone coping 10 inches wide, the remainder of the width of the wall at top being occupied by the back gutter. The front wall is of 14-inch work, continued three courses above the ground level, where it diminishes to 9 inches, having a half-brick set-off all along, and foundation with three courses for footing 2 feet below the ground level. The same dimensions are maintained in the two end walls, except at the steps down to the stove-room, where the end wall is 6 feet below the ground level, and built with an arched doorway leading to the stove-room, 6 feet high by 3 feet 3 inches wide, fitted with a plain sheeted wooden door and related casing. The division wall is of 9-inch work, same depth as the end wall of the hot-house.

6. "The front wall is covered by a wall-plate of Memel fir, 12 inches by 3 inches, with 11 uprights, 4 feet 9 inches high, mortised into it, each 6 inches by 6 inches, set 3 feet 7 inches apart from centre to centre, and surmounted with a cornice-plate of Memel fir, 15 inches by 8 inches, moulded on the front side, and having a gutter 8 inches wide by 3 inches deep formed on its upper side, supported by ornamental trusses 18 inches deep, and fixed one to each upright. These trusses may either be made of terra cotta or carved in sound wood. A 2-inch iron or leaden pipe in one corner will convey the rain water from the gutter into an iron cistern 4 feet long by 12 inches wide by 18 inches deep, fixed beneath the front shelf in the hothouse. The gutter and moulded front are to be continued along both ends over the doors, with trusses, &c., as per front elevation, fig. 1, Plate XVII.

7. "Each of the end and division walls is to be provided with a pannelled and glazed door, 2 feet 6 inches wide by 6 feet 3 inches high, set in related casing, opening in two halves, set at the distance of 18 inches from the inner side of the front wall, and provided with proper locks, bolts, hinges, and knobs. A relate is to be formed all round each of the front lights to receive the sash-frames. The front lights may either be hung on pivots a little above the centre, or on hinges at the top, to open with a ruck and staple to each at the lower edge.

8. "The front lights are to be formed in two halves, the upper half sliding over the lower in a groove formed for that purpose on the sides of the principals. The ridge-board is to be of sound fir, 12 inches by 2 inches. The principals, each 12 inches by 3 inches, are to be spaced to correspond with the uprights of the front, and to be met at the ridge-board by corresponding principals of the back roof notched on to the wall-plate of the back wall. The lights of the back roof are to be hinged to the wall-plate and opened by a shaft and levers, as will be described hereafter under the head of Ventilation.

9. "A shelf of 1½-inch slate, or of 2-inch tooled Yorkshire stone, 16 inches wide, is to run all along the front inside, level with top of wall-plate, supported on neat cast-iron uprights at intervals of 4 feet, and along the two end walls, except at the doors. A chimney, 14 inches by 9 inches, is to be constructed in the back wall, in the position indicated on the plan, fig. 1, Plate XVII., communicating with the stove-room below. It is to be continued in brick to the height of 22 feet above the ground level, and surmounted by an ornamental stone cap, 21 inches high, of the form shown in the drawing, with an opening through it, 14 inches by 9 inches, for passage of smoke.

10. "The front walk is to be 2 feet 10 inches wide from the edge of the front shelf. There is also to be an end walk in each house 2 feet 3 inches wide from edge of shelf, and in the green-house a cross walk close to the division wall, also 2 feet 3 inches wide. These walks are all to be paved with 2-inch tooled Yorkshire flag. The end walk in the hot-house is to be elevated 9 inches where it passes over the stove-room, by means of two stone steps with 4½-inch risers and rounded nosings.

11. "The central portion of the green-house may either be paved with 2-inch tooled Yorkshire flagging, and covered with a wooden stage for flowers, consisting of shelves 12 inches wide, or it may be enclosed by a 9-inch wall all round, 2 feet high in front and 4 feet at the back, covered with a wall-plate of deal, so as to form a pit. The central space in the hot-house may be treated in the same manner, according as the requirements of the owner may be in favour of flowers or of fruit.

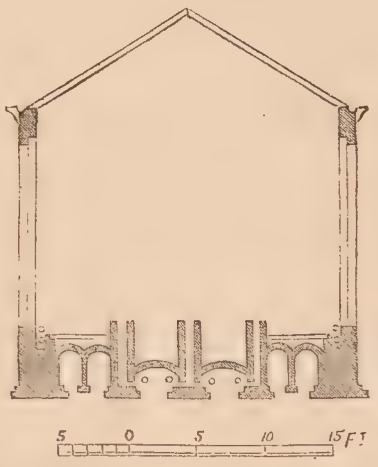
12. A stove-room, 13 feet long by 6 feet wide by 6 feet 3 inches high, should be formed under the hot-house against the back wall, its other side being a 9-inch wall on footing-course, and its end being formed by the division-wall, in which an arched opening, 14 inches by 9 inches, must be left 5 feet above the floor, to connect with foot of chimney. The floor of this room may be paved with tiles or bricks, laid on the flat. The boiler of the hot-water apparatus for heating the two houses must be fixed at its further end. The stove-room must be approached by a flight of nine brick or stone steps, 28 inches wide, with 7-inch risers and 9-inch treads, having a landing at the bottom 28 inches square, paved as the stove-room, the steps to be enclosed by a 9-inch side wall with stone coping."

13. Conservatories are of a much more pretentious character than green-houses; if, indeed, there be any real distinction between the structures, further than this, that in a conservatory, cultivated borders may be placed, in which the plants may grow, while in green-houses the plants are reared in pots placed on stages; but even this distinction may be set aside, for in many conservatories, even of considerable size, and possessed of much architectural design and decorative detail, the plants are reared in the same manner as in green-houses. The following remarks on conservatories by Mr. M'Intosh, in his valuable and exhaustive work, "The Book of the Garden," will be read with interest and advantage:—

> "The situation of the conservatory may be on the lawn or in the flower-garden, but not in the kitchen or fruit-garden, and in such situations it should be a detached building, and glass on all sides. It is often also attached to the mansion, and forming part of it, as at the Deep Dene in Surrey, and the Grange in Hampshire, to both of which highly architectural residences the conservatory forms a useful and appropriate appendage. They are often detached, as at Alton Towers, Sion House, the large one at Chatsworth, that at Dalkeith, and others. In style they vary like other buildings, but they should always be—particularly if attached to the mansion—of the same style of architecture. This rule is, however, not always attended to; for that at Sion House, designed by Fowler, is in the Italian style; that at Alton Towers in the Grecian or Roman; and that at Chatsworth of no particular style whatever. There is, however, attached to that princely residence a large and excellent conservatory, quite in accordance with our views, as forming part, as it were, of the house.
>
> "Architecturally speaking, there is no impropriety in this; but horticulturally speaking, a very great deal. In such cases it were better to place the conservatory at the very extremity of the buildings, and to connect it with the mansion by a glass corridor, of a height, and in a corresponding style, with the conservatory's elevation. This would produce the architectural effect wished for, and the conservatory, extending beyond the line of front elevation, and placed rather in rear of it, would not mar the effect, as it would be considered an independent building. This corridor should have its roof fixed, and the front windows moveable, so that they might be taken away during summer if desirable. The wall of the corridor should be covered with camellias, oranges, and similar hardy evergreen plants, planted in the soil under the floor, which should be covered with polished pavement or encaustic tiles. This corridor would form, as it were, a long narrow conservatory when viewed from the living-room, with which it should be connected, and doubtless would, even when seen in perspective, have a less grand and imposing effect than a broader and more spacious structure; but it would be calculated to afford a great amount of enjoyment to the lover of plants as well as great variety in passing along it towards the conservatory. It would also offer an excellent means for taking exercise in bad weather, and also become an interesting promenade at all times. There is no necessity that such a corridor should be carried its whole length in a direct line; it may recede and project according to the breaks in the building, and from the conservatory it may be continued to the stables or any other place of usual resort" (p. 360, vol. i.).

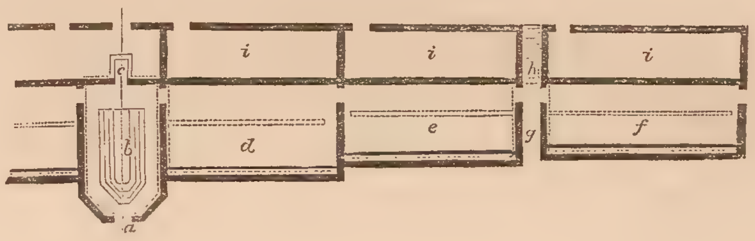
14. In Plates XVIII. and XIX. we give designs of conservatories of a superior description; and in Plate XXI., figs. 1 and 2, of a less pretentious character. In fig. 17, Plate XXI., we give the front elevation of the conservatory in the noble range of *garden structures* erected at Worsley, the seat of the Right Honourable the Earl of Ellesmere, near Manchester, from the designs and under the superintendence of the gardener-in-chief, Mr. Mitchell. In fig. 3 we here give a transverse section through centre of conservatory, shown in plan in fig. 4, in which *a* is the main entrance, *b* stage for flowers, *c* space for the boilers.

Fig. 3.



Section through centre of Worsley Hall Conservatory, on line *a b c* in Plan, Fig. 4.

Fig. 4.



Half Ground Plan of Worsley Hall Conservatory, Peach Houses, and Vineries—Scale, 20 feet to the inch.

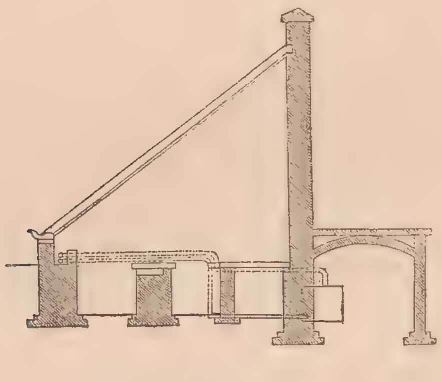
15. Vineries.—As remarked by Mr. M'Intosh in "The Book of the Garden," a wider range of form, size, and details of construction, is allowable in vineries than in other forms of structures adapted for the growing of fruit. This is owing to the adaptability of the plant to a wide range of circumstances, so that the construction of the house in which it is reared does not exercise such a marked influence on its growth; thus, the difference between a moderately well-constructed and a really badly-constructed house may not be apparent except to experienced observers. But, as Mr. M'Intosh very acutely remarks, that "there is, however, a right and a wrong mode of construction is undeniable." The same authority suggests a "curvilinear-roofed house" adapted for early forcing. We do not here give the drawing by which it is illustrated, but it very much resembles the section of vinery in fig. 7, Plate XVII. The ventilation is effected in front and back, as in the above drawing, and the heating is secured by hot-water pipes placed near the front wall, additional heating space being obtained by making the back wall hollow for a certain part of its height, and running along it the smoke-flue of the hot-water boiler furnace. The vines, Mr. M'Intosh suggests, may either be trained along the front or the back. The foundations are proposed to be carried up solid, the roots by this means being "prevented from reaching the cold border without, which is of vast importance to vines early excited, and does away with the necessity for concreting the surface, heating by vaulting underneath, forming hot beds on the outside, and all the other means hitherto tried with so little advantage. . . If planted in front the vines should be traced to a trellis 18 inches from the glass, and allowed to descend a part of the back wall. Or if planted at the back they should be trained 2 feet from the wall, and partially down the glass roof also; but in both these cases they should not be left so thick as to cause shade or obstruct the light, and hence in such cases the spur system of pruning should be adopted. The width of such a house may be 6 or 7 feet, and the height 9 or 10 feet."

16. Space at our disposal does not permit of us giving descriptions and illustrations of all the forms of vineries for early and late forcing of vines; those of our readers who are desirous to go into the subject will find it exhausted in the chapter on "Vineries" in the "Book of the Garden," at p. 299, vol. i. We can only glance at a few arrangements, all of which have been carried out in practice. In fig. 7, Plate XVII., we give a section of a vinery erected by Messrs. Shanks & Son, of the Dens Iron Works, Arbroath, for — Campbell, Esq., at Cheadle, near Manchester. The peculiarity of this construction is the adaptation of a curvilinear or elliptic girder of cast-iron, of section shown in fig. $\frac{7}{a}$, Plate XVII. This is fitted as shown in fig. 7, same Plate, with simple tie-rods, so that all rafters,

cross-bearers, stays, and columns, so often encumbering horticultural structures, are dispensed with. The design is by Mr. Halliday, gardener-in-chief to the Right Honourable the Earl of Mansfield at Scone Palace.

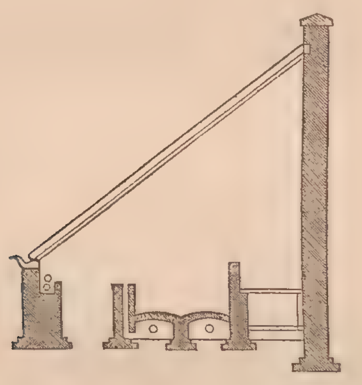
17. In fig. 5 we give a section of the *vinery* forming part of the range of buildings erected at Worsley, and alluded to in par. 14. Fig. 6 gives a section ot the vinery *e*, fig. 4, and fig. 7 an alternative mode of construction. For all the details of construction and fitting of these vineries see the descriptive specifications of the Worsley Hall garden structures in a succeeding paragraph (25).

Fig. 5.



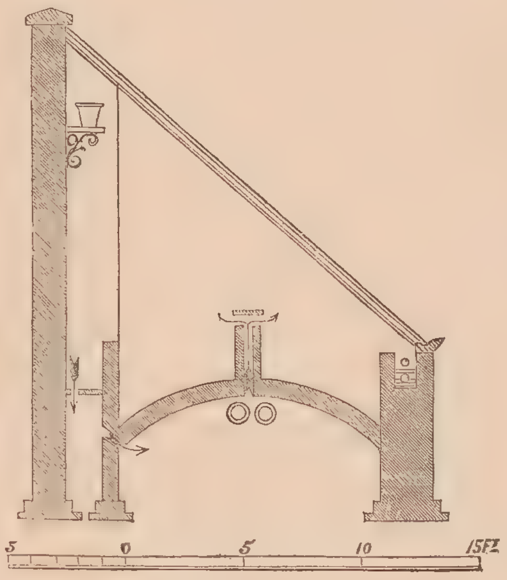
Section of Vinery (at Worsley Hall) *e* in fig. 4.—Scale as in fig. 3, par. 15.

Fig. 6.



Section of Vinery *d* in Fig. 4.—Scale as in fig. 3, par 15.

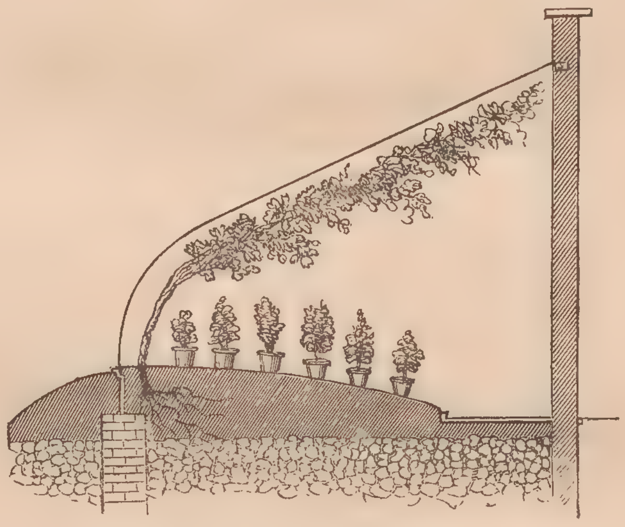
Fig. 7.



Alternative Section of Vinery, *e*, fig. 4.

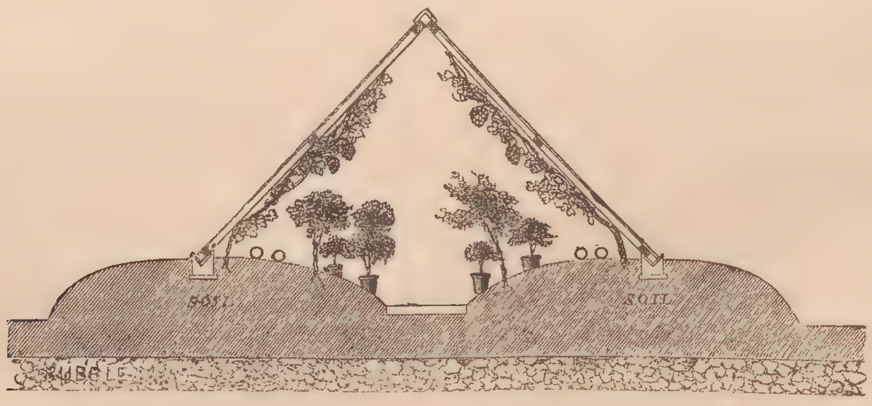
18. Fig. 8 is the section of a vinery on Dennis's patent

Fig. 8.



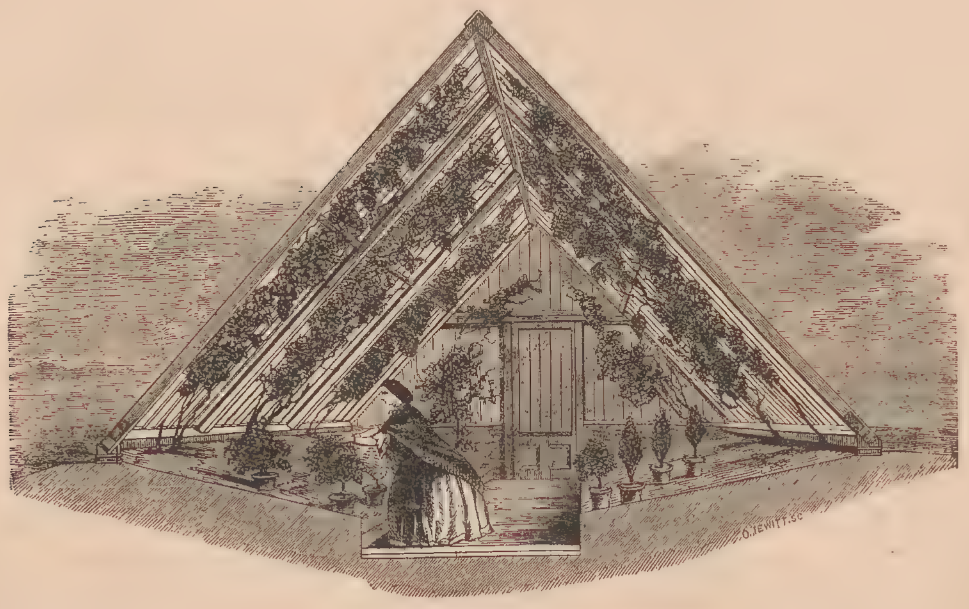
Section of a Vinery on Dennis's Patent Construction.

Fig. 9.



Section of Span-roofed Vinery on Sir Joseph Paxton's Patented System.

Fig. 10.

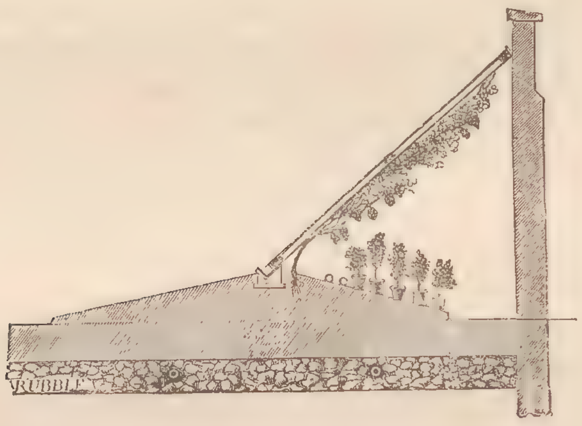


Span-roofed Vinery on Sir Joseph Paxton's Patented System.

construction, of which a full description will be found in a succeeding paragraph, under the department of this paper entitled “Recent Improvements in Garden Structures.”

19. In figs. 9, 10, we give sections of span-roofed vineries on Sir Joseph Paxton's Patented Plan, the principles of construction of which will be afterwards described. The vinery in fig. 9 is composed of 10 feet sashes, set at an angle of about 45°, and gives an internal width of nearly 14 feet. The borders, both inside and outside the house, should be raised high to give a good internal elevation. The fruit trees, where used as an “orchard house,” may be grown either in pots or in the border without heating apparatus, or with a single or double flow and return of hot-water pipes as shown. A vinery, as in fig. 10, composed of 14-feet sashes, placed at an angle of 45°, gives an internal width of about 19 feet, and of 16-feet sashes of 22 feet. Fig. 11 is a section of a lean-to vinery on the same principle of construction, composed of 10, 12, or 14-feet sashes placed against a wall. The raising up of the front border not only gives more space within, but also, having the border made for the most part on the surface, is much better for the vines, and is certain, with proper management, to secure good flavoured fruit. “The walk is made near to the back wall, and the hot-water pipes should lie on the surface of the soil about 18 inches from the front; plants in pots (either fruit trees or other plants) may stand upon the soil, and if space is important, fruit trees may be trained to the back wall.”

Fig. 11.



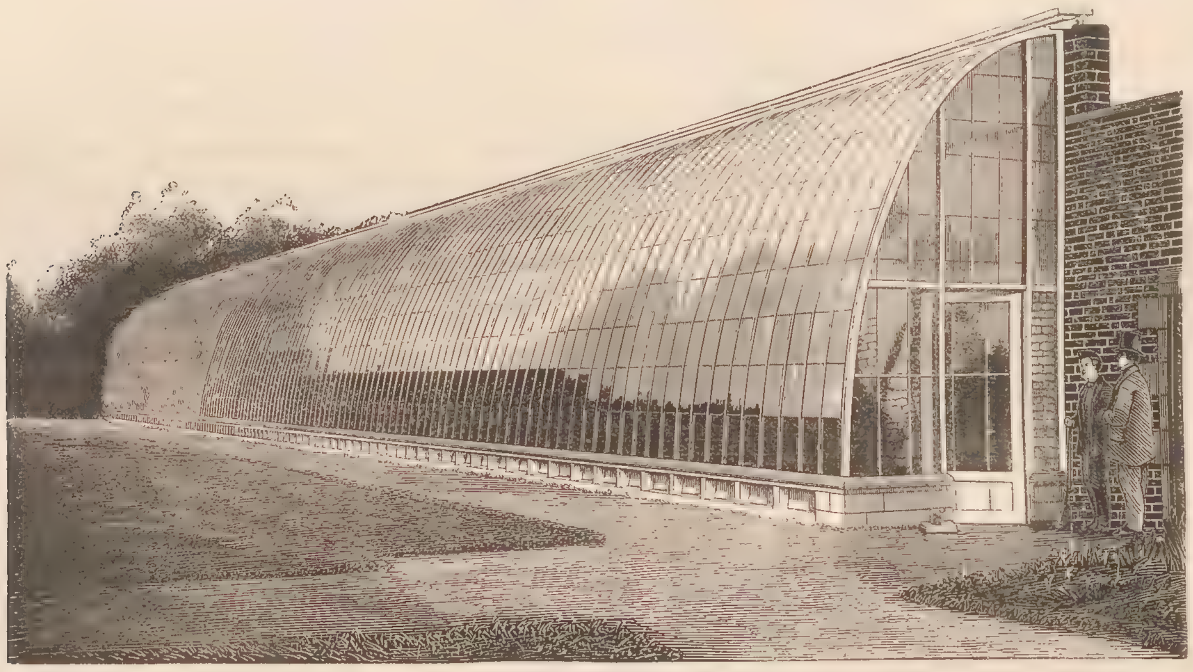
Section of Lean-to Vinery on Sir Joseph Paxton's Patented System.

20. The slope or angle of the roof of vineries, as in sections, figs. 5, 6, 7, and 11, is an important point, and should not be invariable under all circumstances, at least the general opinion amongst authorities is that a steep roof is required for early, and a flat roof for late, or summer vineries. Some remarks on this subject will be found under the department of this paper treating of “Points to be considered in the Arrangement and Construction of Garden Structures.”

21. Peach-houses.—There is comparatively little difference between structures adapted for the growth of peaches and those for vines, except in the mode of training the peach trees. In fig. 12 we give a view of a range of peach-houses erected at Scone Palace, the principle of construction being the same as described in par. 16. In place of lean-to erections, peach-houses may be span-roofed, as in fig. 9. In fig. 13 we give a section of a lean-to peach-house, or vinery, constructed by Mr. T. G. Messenger of Loughborough.

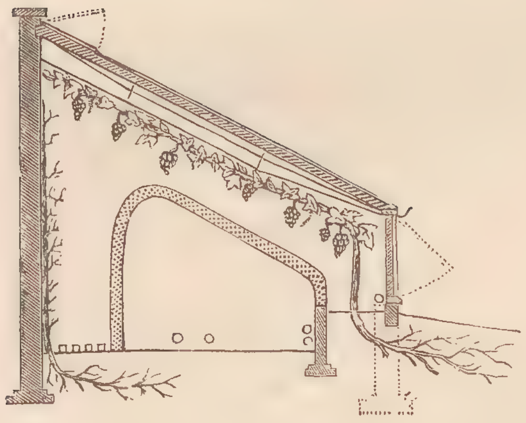
22. Pineries.—Pine-houses vary little in construction from vineries or peach-houses. They are of two kinds also, as “span-roofed,” fig. 14, or “lean-to,” as in fig. 15. The span-roofed houses are in every respect the best for rearing the pines. Pineries are provided with central beds, which are heated in various ways, as “by the fermentation of vegetable substances, such as tanners' bark, leaves, flax refuse, stable manure, moss, &c., or by tanks of water heated by steam, or

Fig. 12.



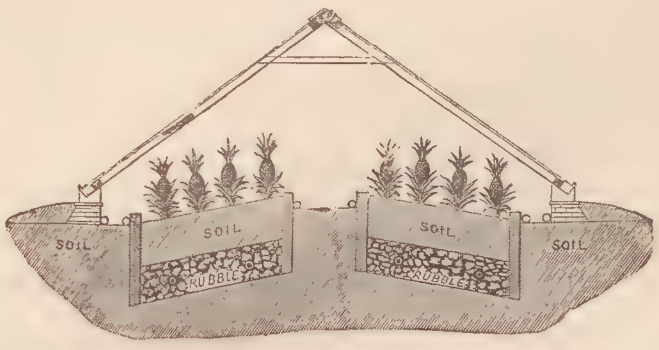
View of Peach-house erected at Scone Palace by Shanks & Sons of Arbroath, from the designs of Mr. Halliday.

Fig. 13.



Section of Lean-to Peach-house, or Vinery.

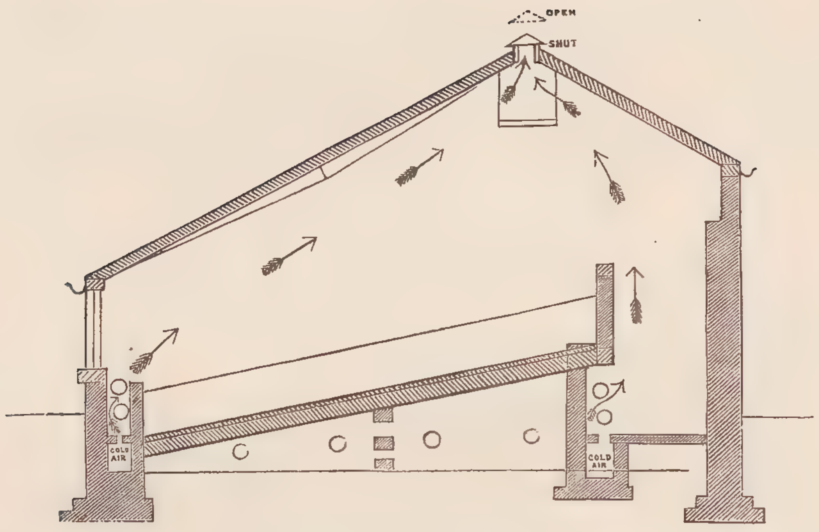
Fig. 14.



Section of Pinery on Paxton's System.

ON GARDEN STRUCTURES.

Fig. 15.



Section of Pinery at Snelston Hall.

from a hot-water boiler connected with them, or by admitting steam into masses of broken stones or open brickwork, and sometimes by hot-water pipes passing through a hollow chamber beneath the bed in which the plants are plunged, planted out, or set, and occasionally on a stage or platform in the manner of green-house plants, as recommended by the late T. A. Knight, Esq." ("Book of the Garden," vol. i. p. 331.)

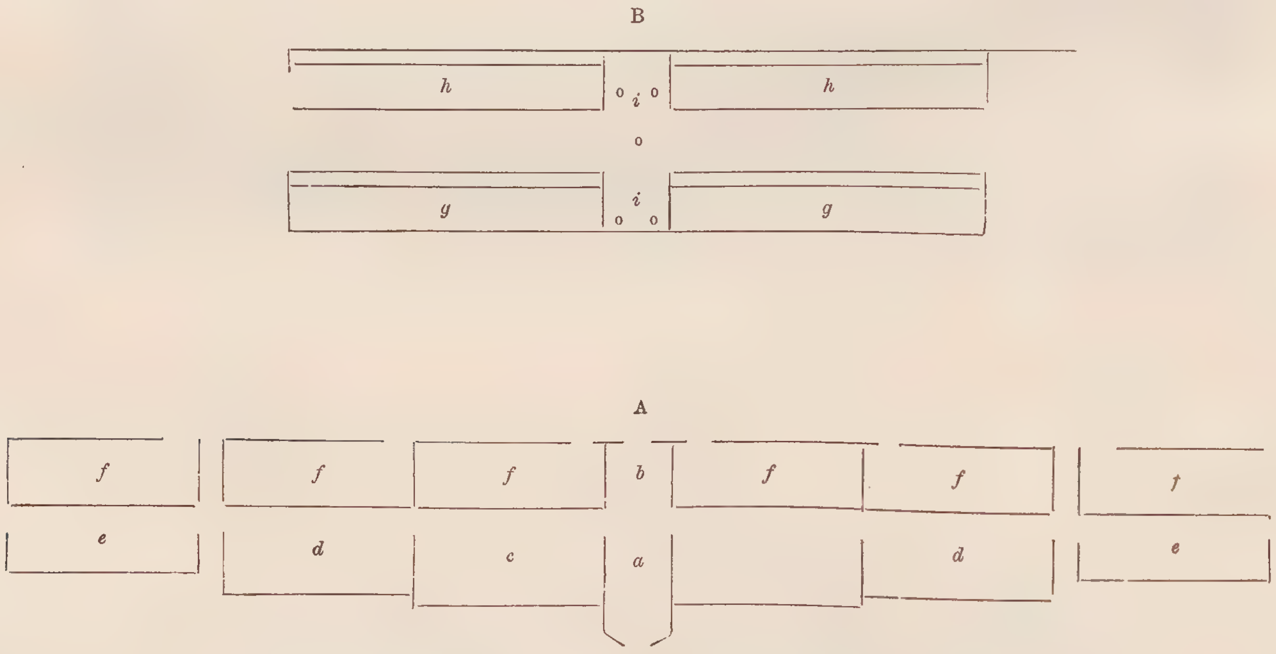
23. In fig. 14 we give a section of a pine-house erected on the patented principle of Sir Joseph Paxton. When the sashes are placed at an angle of 30° to 35°, 10-feet sashes give an internal width of nearly 17 feet, and the 12-feet sashes nearly 20 feet. If a walk of 3 feet be allowed through the centre of the pit, and 1 foot 6 inches on each side near the glass for the pipes to lie, there will then remain two good pits for pines. In fig. 15 the beds are shown on each side of the central walk, heated with 4-inch pipes passing through a bed of rubble composed of broken brickbats, or stones, laid open and loose to allow of the diffusion of the heat. These rubble chambers should be about 15 inches deep, and if a little long litter be laid over it, the soil will be prevented from falling through amongst the rubble and stopping it up. In fig. 15 we give the section of a pinery erected by Mr. T. G. Messenger of Loughborough for J. Harrison, Esq., of Snelston Hall, Derbyshire. In fig. 21, Plate XXI., we give a section of the pineries at Worsley Hall; a full description of the construction of these will be found in par. 25.

24. Orchard-houses.—A simple but effective species of garden structures was introduced under this name by Mr. Rivers (the Nurseries, Sawbridgeworth, Herts), and has, from the facilities it affords for the cultivation of all kind of fruits, been very much used. "The objects aimed at in the adoption of these structures were to produce in our varying climate as much fruit as possible within a small space, to afford, by rendering cultivation simple and easy, a large amount of pleasure to the cultivator, and also to make the structure itself, at a small cost, an ornament to the garden in which it was placed." The orchard-house as introduced by Mr. Rivers was simply a glass-shed, span-roofed, the sides up to a height of 4 or 5 feet being boarded, the span-roof glazed. Ventilation was secured by having one of the boards on each side hung upon a hinge, so that when opened a draught was established. In the centre of the shed was a path, and on each side of it a border composed of earth and manure resting upon a mass of rubbish to keep the border porous. The fruit trees are placed in *pots*, and these again upon the border, the roots of the trees passing through the apertures in the pots into the soil of the border. Orchard-house construction has been greatly improved by the patented arrangements of Sir Joseph Paxton, hereafter to be described.

25. *Descriptive Specification of the Conservatory, Peach-houses, Vineries, and Pineries, at Worsley Hall.*—As conveying information of a practical nature connected with the structural details and arrangement of the leading kinds of *garden structures*, we deem it of importance to present our readers with descriptive specifications of the *conservatory*, *peach-houses*, *vineries*, and *pineries*, forming the noble range of garden structures at Worsley Hall, the seat of the Right Honourable the Earl of Ellesmere. This we take from a work edited by the author of the present paper, entitled "Conservatories: their Arrangement and Construction." For the materials illustrating this valuable series of constructions the editor was indebted to the courtesy of Mr. John Mitchell, who designed them, and superintended their erection, and who laid out the beautiful grounds by which they are surrounded.

26. Fig. 16 gives a rough block plan, showing the general arrangements of the range of structure. *a* the conservatory; *b* boiler space; *e e* peach-houses; *c c*, *d d* vineries; *f f* sheds. Behind this range, and 45 feet distant, is another range of buildings, containing a double set of pineries, *g g*, *h h*.

Fig. 16.



General Plan of Garden Structures at Worsley Hall—Scale 20 feet to the half-inch.

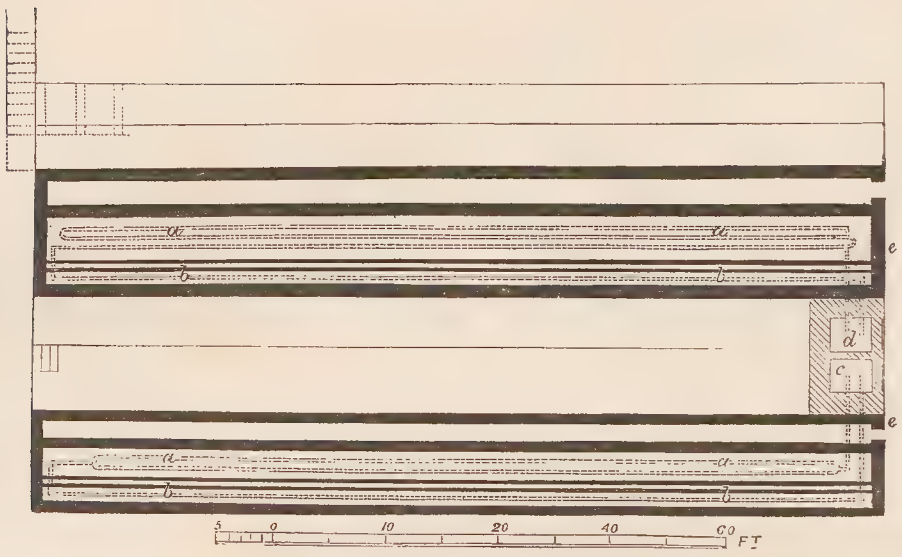
27. Fig. 17, Plate XXI., is front elevation of central part of conservatory. The ends are brought up, and represent the terminations of the range.

28. Fig. 4 (see par. 15) is half ground plan of range A in fig. 16. *a* main entrance to the conservatory; *b* stage for flowers, &c.; *c* space for boiler; *d* peach-house; *e* vinery; *f* vinery; *g* passage; *h* stairs to boiler; *i i i* sheds.

29. Fig. 17 is half plan of range of pineries in part B, fig. 16. The dotted lines *a a* show ranges of 6-inch heating-pipes; *b b* ranges of 4-inch pipes; *c d* the boilers.

ON GARDEN STRUCTURES.

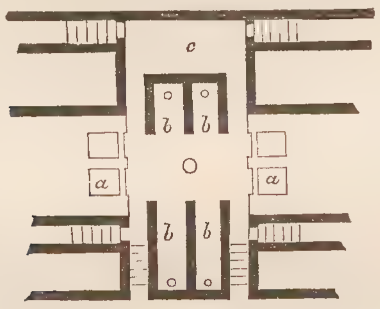
Fig. 17.



Half Plan of Range of Pineries, B in fig. 16.

30. Fig. 18 is plan of underground vaults containing the boilers and fuel. These are centrally situated at *i i*, between the two sets of pineries *h h*, *g g*, fig. 16, as at *i i*, and come into the plan, fig. 17, at *e e*. In fig. 18 *a a* are the boilers; *c c* the fuel places; *c* recess for pots. Fig. 21, Plate XXI., is a transverse section of the pineries to a larger scale than in preceding fig. 3.

Fig. 18.



Plan of Underground Vaults of Worsley Conservatory.—Scale as in fig. 17.

31. The following is the descriptive specification of these various structures:—

"Fig. 17, Plate XXI., is a front elevation of part of the principal range, showing only a small proportion of the elevation of the houses forming the wings on either side, the illustration being chiefly confined to the elevation of the central green-house, or conservatory, for plants in flower. This central house is in the Tudor style of architecture, in conformity with that of the mansion. In plan (see fig. 4) it is a parallelogram, with a semi-octagonal end, the end being projected beyond the general line of the front of the range. The central door is in the front side of the semi-octagon, and is approached by a flight of three stone steps, 7 feet wide, with 9-inch risers and 12-inch treads, with side-stones and a 12-inch pedestal on each side. There is another stone step, 5¼ feet wide, with 9-inch riser, by which the visitor attains the level of the conservatory floor. Owing to the slope of the ground from back to front, the level of the path in front of the steps, which leads through the centre of the garden up to the green-house, is 3 feet below the general floor level, the external vine border which runs along the front of the range being sloped off on either side to accommodate these two levels to each other, as denoted by the sectional lines. The centre of the conservatory is occupied by a stage of four 12-inch shelves, 20 feet long by 14 feet wide (see *b*, fig. 4), surrounded by a path 4 feet wide along the front and both sides, and 5½ feet wide along the back, formed of stout stone flagging 4 inches thick (see section, fig. 3), supported on two 4½-inch brick arches. The foundations of the outer walls are of 18-inch brickwork. Those under the centre of the pathway forming the springing of the said arches are of 4½-inch brickwork, and the walls in the centre to support the stage are built hollow of 14-inch work. All these foundations have two footings, each of two courses, except those of the 4½-inch walls, which have only one footing of two courses, and are sunk 4 feet below the outer ground level. The 14-inch dwarf walls under the stage are built hollow for circulation of air, as will be hereafter described. A space 18 inches wide by 9 inches deep runs along the front and both ends against the outer wall to receive the two 4-inch hot-water pipes as per section. Two flat arches of 4½-inch work are turned between the dwarf walls under the stage, the crowns of which are 18 inches beneath the level of the path, the spaces beneath them being connected by half-brick openings 9 inches apart, just above the upper footing-course, with the hollow spaces in the 14-inch dwarf-walls. In each of the spaces under these two arches, just above the half-brick openings, are fixed two 4-inch hot-water pipes, as shown in fig. 3, the heat from which passes through similar half-brick openings left in each of the flat niches into the centre of the house. The base-course all round the outside of the house is of 12-inch cut stone, from which spring six stone pilasters, each 12 inches square by 13 feet 9 inches high, with handsome trusses, as per elevation, fig. 17, Plate XXI., supporting the stone cornice, 12 inches wide by 21 inches deep, ornamented with sunk panels, each 6 inches square, with appropriate moulding all round each, and having a 9-inch moulding projecting 9 inches all along the top of the cornice. A semi-circular gutter, 6 inches wide by 6 inches deep, is sunk in the upper side of the stone cornice to receive the rain-water from the roof, which is discharged into the drains by 1-inch leaden pipes, one behind each pilaster. Each pilaster is surmounted by an appropriate finial above the cornice.

"The door, 5½ feet wide by 9 feet high, is in two halves, opening inwards in the centre. (A section of the door-frame is given in Plate XXI., fig. 24.) The windows are each in two sections, the lower section corresponding in height with that of the door. The upper section of each window all round, opens on pivots, to permit access of air when desired.

"The roof consists of a ridge-plate, 12 inches by 3 inches, supported by 8 rafters, each 6 inches broad by 3 inches deep, the lower ends of which rest on the upper side of the stone cornice. A finial of wood, corresponding with those of stone over each pilaster, is fixed on the apex at the front end of the ridge-plate, where the front rafters meet. The back wall is carried up square to the height of 19 feet, the whole width of the house, except at the centre, where it follows the shape of the roof, terminating in a point just above the central ridge-plate. It is 18 inches thick, covered with a bevelled projecting stone coping, 2 feet broad by 12 inches deep, and is terminated at either end by a panelled stone pedestal, 15 inches square by 26 inches high, with plinth and upper moulding, surmounted by a stone finial of the same form and size as those before mentioned on the cornice. (See Section of Cornice, fig. 23, Plate XXI.)

"There is a door in the centre of the back wall of the conservatory, 3 feet wide, for access into the back shed.

"The back wall of this entire range of houses is of the same thickness as that of its central conservatory, viz., 18 inches. The front, division and end walls are of 9-inch brickwork, carried up 2 feet above the external ground level, surmounted with a handsome moulded stone wall-plate, 5½ inches deep by 14 inches broad on the top, having a semi-circular gutter, 6 inches broad by 3 inches deep, hollowed out of its upper side along the front and ends of the whole range, to receive the rain-water from the roof, and connected with the drains by an earthen or iron tube at the end of each house.

"The total length of the range, inclusive of two passages (each 3½ feet wide), between the two end houses and those next adjoining them, is 255 feet.

"Fig. 3 is a section of the central conservatory just described; by reference to the description of the elevation its details will be fully understood.

"Fig. 6 is a section of each of the two vineries immediately adjoining the central conservatory on either side, as *c c* in fig. 16. They are each 35½ feet long, 18 feet wide, 5 feet high in front, and 15 feet high at the back wall in side measure. (See general plan of the range, fig. 16.)

"The details of their front walls above the ground level have been already described. Below that level the foundations of the front walls are constructed 30 inches thick, so as to form a gutter near the external ground level, and just within the front wall, 15 inches wide by 9 inches deep, the front of the gutter being formed of three courses of brickwork laid on the flat. The sides and bottom of this gutter are well lined with Roman cement. These foundations are carried down 5 feet below the external ground level, having two footings, each of two courses, and being formed through the entire length into a series of flat niches, 3 feet wide by 4½ feet high, with a pier 12 inches wide between every two arches. These arches are for the passage of the vines into the houses below the ground level from the external vine-border, running in front of each house in which they are planted.

Next within the gutter is the front path, 3 feet wide, sunk 3 feet below the external level, and based with 2-inch tooled flagging. In some of these houses the space occupied by this path is filled up with compost or tan, so as to give increased pit-space for growth of pines. The front wall of the pit is of 14-inch hollow brickwork. The width of the pit is 6 feet inside measure, its back wall being formed of 14-inch brickwork below the back walk, and of 9-inch work above, the remaining 5 inches forming a set-off to carry the flagging which forms the back walk. Along the centre of the pit is a 9-inch dwarf wall, 12 inches high above the footings, to support two flat arches of 4½-inch work, which form the coverings of two warm chambers, 12 inches high, extending all under the pit, and connected together by spaces left through the dwarf wall. These are heated by hot-water pipes, as will be hereafter explained, and being connected by suitable openings with the hollow space in the front wall of the pit, their heat is by that means communicated to the house when desired, or confined to the warm chambers by coverings placed on the top of the front wall of the pit. The footings of all these walls correspond in level exactly with those of the front wall of the house. The back walk is formed of 4-inch tooled flagging, supported 3 feet above the footings by the aforesaid set-off on the front edge, the back edge being supported on a brick pier at every joint of the flags. Narrow openings, 6 inches wide by 12 inches long, are cut out of the flags close to the back wall to permit the air of the house to pass downwards under the back walk, and thence into the warm-air chambers before described, by which a constant internal circulation of air is maintained.

"The foundations of the back walls are 5½ inches below the external ground level throughout the range, and are built on two footings, each of two courses of brick. These walls are carried up in 9-inch brickwork to the height of 15 feet above the back walk, or 18½ feet above the upper footing-courses, and are there surmounted by a bevelled stone coping of the same size and form as that already described for the back wall of the conservatory.

"The rafters of these two vineries are fixed at an angle of 42°, their lower ends being notched out 6 inches by 4½ inches, so as to rest on the stone wall-plate as far as the gutter, and their upper ends firmly tenoned and secured by long screws to a back plate of timber, 9 inches by 4½ inches, built into the back wall five courses below the stone coping. The rafters are 11 inches deep by 3½ inches thick in the widest part in section, and are neatly moulded on their lower edge. (See fig. 22, Plate XXI.) The upper edge of the rafter is worked to the form shown in the same section, so as to form a cap-moulding projecting over the side of the sash. The narrow part of the rafter, against which the sashes run, is 5¾ inches deep by 2⅛ inches thick, and in the centre of this depth on each side a fillet of hard wood, ¾ inch square, is let into a groove formed for that purpose, and secured by wood screws for the upper half of each sash to slide on, the lower half sliding on the upper side of the thickest and lowest portion of the rafter.

"The sashes are each in two halves, each half having a top bar and bottom bar, 4 inches by 2½ inches, and side bars of the same scantling. The upper sash is maintained in any desired position by a strong sash-cord secured to its top bar, passing over a pulley screwed to the back-plate of the house, and terminating in a balance-weight hanging against the back wall, by which it is raised and lowered at pleasure. The sash-bars are of wood, 2 inches deep by ¾ inch broad in the strongest part, and are tenoned and mortised into the top and bottom bars of their respective sashes at distances of 10 inches from centre to centre.

"The next two vineries, *d d*, fig. 16, one on each side, contiguous to the two just described, are of very similar construction, the chief differences being in dimensions and in the foundations. They are each 36½ feet long by 16 feet wide, 2½ feet high at the front, and 15 feet high at the back wall, inside measure. (See general plans, figs. 4 and 16.) The front wall of these two houses, with its underground arches, stone wall-plate, and gutter, is precisely of similar arrangement and construction as that described in the other two vineries. Immediately behind the gutter is the front path, 3 feet 9 inches wide by 3 feet 3 inches below the external ground level, its flagged floor resting on the upper footing-course, as shown in section (fig. 5). This space may be filled in with compost as before described, so as to give increased accommodation for plants if desired, in which case its surface will be level with the bottom of the gutter. Behind it is a wall, 30 inches thick, covered over at the height of 3 feet above the footings with flags or tiles, 3 feet broad, forming a convenient stand for two 4-inch hot-water pipes, and for large plants in pots. Behind this is a bed of earth or compost, 3½ feet wide, and then a dwarf wall, 12 inches thick by 3 feet high, on which rests one edge of the tooled flagging, 4 inches thick by 5 feet broad, which forms the back walk, the other edge resting on a 5-inch set-off in the 9-inch back wall, which is built 14 inches thick in the foundation for that purpose. In all other respects as regards back wall, coping-stone, rafters, and sashes, the description of the two wider vineries will apply to these two houses.

"Fig. 7 (p. 4) represents in section another arrangement which was proposed and afterwards adopted in one of the last two vineries, *d d*, fig. 17. In this arrangement the front wall and gutter are as previously described. There is no front walk, the whole space between the gutter and back walk being a bed, 11½ feet wide, supported on a 9-inch brick arch springing from the foundation-wall in front, and from the back wall of the bed at the back. A hollow wall, 14 inches thick, is built 2 feet high on the crown of this arch, having half-brick openings through the arch to admit heated air from the chamber under it into the hollow wall, which, being covered with flat tiles 18 inches square, elevated 3 inches above the wall by bricks with openings left between them, discharge the bottom heat into the vinery in the manner indicated by the arrows. The back walk in this arrangement is 2½ feet wide, of stone flagging, with openings through it into the hollow space beneath, whence the air passes into the bottom chamber to be re-heated through openings left for the purpose in the back wall of the bed, just under the springing of the arch. The space on either side of the central hollow-wall being filled with earth, or compost, forms a convenient bed for the immersion of plants in pot or otherwise.

"Next beyond these two last vineries, *d d*, fig. 16, on each side, is a gravelled passage, 4 feet wide, with a door 2½ feet wide opposite to it in the back wall for access to the boiler-shed immediately behind it.

"Beyond these passages are the two peach-houses, *e e*, fig. 16, which form the extremities of the range. They are each 39 feet long by 14 feet wide. Their front and back walls are precisely like those of the vineries in every respect, as also the rafters, sashes, and sash-bars. Their floors, however, are perfectly flat, and are formed of loose earth, with the exception of the back walk, 3 feet wide, which is of tooled flag, 4 inches thick, embedded therein level with its surface. The iron frames on which the trees are trained are screwed into the under side of the rafters, one bar of 1½ inch by ½ inch iron to each rafter. The lower ends of these bars are driven down into the soil. They are drilled through at intervals of 2 feet, with ⅜-inch round holes, through which ⅜-inch round rods are passed longitudinally the whole length of the house, thus forming a sort of trellis-frame at a distance of about 18 inches below the glass. At the height of about 2½ feet below the glass an open shelf, 18 inches wide, formed of slips of wood 2 inches by 1 inch by 2 inches apart, for small plants in pots, is supported on neat wrought-iron brackets driven into the back wall.

"With the exception of the conservatory these houses have no upright front lights, the rafters being notched at the lower end and supported on the stone gutter, fig. 23, Plate XXI. The front wall is 2 feet high, outside measure. Each of the vineries and peach-houses consists lengthwise of 10 bays, each bay being from 3 feet 3 inches to 3 feet 10 inches wide from centre to centre of the rafters. The whole of the range is glazed with patent polished sheet-glass, 21 ounces to the square foot, in lengths of 3 feet, by 7 and 8 inches wide, the width of the bays and panes varying slightly to suit the different lengths of the houses. The gutter of brick, lined with Roman cement, runs along the front of the whole range, so that a copious evaporation may be produced in any of the divisions when desired.

"A range of sheds, *f f*, fig. 16, 10 feet wide, runs along the back wall of this entire set of hot-houses. The front, end, and division walls, are 9 inches thick, their foundations having two footing-courses, and being sunk

2 feet below the ground level. Their ends and divisions correspond exactly with those of the hot-houses, so that each hot-house has behind it a shed exactly its own length. There are also two passages in the rear corresponding with the two in front, beneath which two of the boiler-chambers are constructed. These sheds have the ordinary lean-to roof, and are each furnished with a door 3 feet wide, and two small windows (not shown in the plan), with cast-iron frames of lattice-work, each 3 feet square.

"We have now to describe the *heating apparatus*, which is arranged in three distinct portions. It is on the hot-water principle, combined with the open tank system for evaporation of water to give a moist atmosphere, and with the chambers beneath the pits and beds for bottom heat, and gives great satisfaction. The boilers are fixed, one under each of the back passages, and the third in the shed behind the centre of the range. The two first are arranged for heating the peach-house and vinery next adjoining them. The central one has to supply heat for three compartments, viz., the central conservatory, and the early vinery on each side of it. The central apparatus we shall first describe. Its boiler is of the saddle shape, of wrought-iron, 4 feet long, 18 inches wide in the fire-place, 9 inches high under the arch, with 6-inch water-way, having one 4-inch rocket on the top, near the front, for the flow-pipe, and two 4-inch ditto, one on each side near the bottom, and towards the back, for the two return-pipes. Each boiler is provided with all the needful appurtenances of ¾-inch draw-off pipe and cock in the front, fire-door, and front, with ash-pit door, flue-doors, bars, and sleepers, to form a grate 30 inches by 18 inches, damper, and flue-door, and is set in brickwork. The approach is by a flight of six steps, with 9-inch risers and 12-inch treads, forming a descent of 4½ feet, and leaving a space for stoking of 3 feet in front of the boiler. The 4-inch flow-pipe leaves the socket on the boiler by an elbow connected with a T pipe, which separates it into two branches, diverging right and left along the back wall, where it has two other branches on each side, one proceeding to the vinery, the other continuing along the side of the conservatory. These four branches are all kept below the ground level till they have passed the doors in the division walls, immediately beyond which they are brought above the floor level by means of double or S elbows. The 4-inch pipe on each side of the conservatory is continued to the front door, where it terminates with a syphon head, by which means it is made to return beneath itself, forming two 4-inch pipes, one over the other, on each side. The lower of these are returned to the boiler by means of double elbows dipping under the doors, and passing through the back wall with elbows to the return-pipe sockets on each side of the boiler. Each of the flow and return-pipes is furnished with a stop-cock to control the flow of water, and consequently the temperature of the pipes. The pipes in the vinery on each side pass under the door in the division wall in the same manner, ascend thence by double elbows to the level of the front gutter, and thence proceed in a double row of 4-inch pipes along the front gutter, the lower pipe being fixed at such a height as to be half immersed in the water of the gutter. Thence they are conducted in a double row of 6-inch pipe along the centre of the house in the course indicated in the same figure (being enlarged by means of two 6 × 4-inch reducing sockets at the end). The pipes in the vinery on each side are also furnished with two stop-cocks, one on the flow and the other on the return-pipe, to regulate the temperature, and to enable any one or more of the compartments to be left cold when required. The 6-inch pipes being fixed one in each of the chambers beneath the pit, are brought down to that lower level by means of two 4-inch elbows, and are thence continued by elbows to their respective return-pipe sockets near the bottom of the boiler.

"The arrangement and size of the boilers and their appurtenances are precisely similar in the other two apparatus, the pipes being arranged in the same manner in each wing, except that, there being no conservatory between the two houses heated, there are only two branches instead of four, and four stop-cocks instead of eight. The pipes along the centre of each peach-house are increased to 6 inches diameter, as in the others, but are only 4 inches as the front pipes, and those in the centre are laid flat on the floor instead of in a chamber underneath. In one of the late vineries they are represented in the sectional drawings as fixed either in a chamber under the bed, side by side, or one over the other on the top of the dwarf-wall.

"There is a cast-iron supply-cistern for each boiler, 3 feet long, 2 feet wide, and 2 feet deep, fixed on wooden tressels in the back shed near the boiler, and connected with it by a 1-inch wrought-iron pipe, having a stop-cock near the boiler to permit the pipes to be emptied without emptying the cistern. Each of these cisterns has within it a ¾-inch ball-cock, supplied by a ¾-inch leaden pipe from a large general cistern fixed in a higher part of the grounds, and the ball-cocks are fixed at such a level that the water cannot fill the cisterns to a greater height than 9 inches, so as to leave room in their upper parts for the water to expand.

"At a distance of 45 feet behind the back sheds of the long range, shown in plan in fig. 16, are the two ranges of pineries, *g g*, *h h*. (See general plan, fig. 16.) They are placed thus far backwards to prevent the shadow of the long range of houses from falling upon them in the morning and evening. If the ground in any similar arrangement should not happen to rise towards the back, as it fortunately does in this instance, owing to the nature of the ground and judicious selection of site, such pineries would require to be placed still further backward. One-half of this range of pineries is shown in plan in fig. 17, and the section in Plate XXI., fig. 21. They consist of an extensive cluster of forcing-pits, four in number, each 75 feet long by 9 feet wide, outside measure, in the front range, and 11¼ feet wide in the back range, the back wall of the front range being 22, and that of the back range 27 inches wide. The width of the pits, inside measure, is 4 feet in the back and 2½ feet in the front range. The back pits are 3 feet higher than those in the front, to accommodate the larger and older plants, and at the same time to prevent the sun's rays from being intercepted by the front range. The back walls are of 14-inch brickwork. The front walls have their foundations 3 feet below the ground level, and are 3 feet thick to the height of 14 inches above that level, at which height they are carried up 9 inches thick in front and 14 inches thick behind, forming a gutter 13 inches wide by 14 inches deep all along the front of each pinery. These walls are built on footings of three courses, and the 9-inch front wall is 2 feet high in the front pits and 3 feet high in the back pit, above the bottom of the gutter, which is well lined at the bottom and sides with Roman cement. The 14-inch back wall of the gutter is built hollow, and the hollow space is continued down to within 14 inches of the foundation, where it communicates, by openings on the inner face of the wall, with a hollow space or chamber under the pit. The foundations of the back walls are all 3 feet below those of the front walls, have each a footing of one course of brick, and are surmounted by a bevelled stone coping, as per section. The wall which separates the pit from the back walk is 9 inches thick, its foundation and footing same as those of the front wall, and is carried up three courses higher than the bottom of the gutter, and covered with a 9-inch tinker wall-plate. Openings of half-brick width are left in it all along, as shown in section, for air to enter the chamber under the pit. This chamber is covered over with a perforated arch of 4½-inch work, set brick-on-edge, and is floored with 1½-inch flags laid on the footings, and well grouted, so as to be water-tight. The 9-inch front wall of the pit which forms the gutter is covered with a bevelled stone coping, as per section. The rafters, fig. 19, Plate XXI., are of cast-iron, 8 feet 10 inches long, 6 inches deep by ½ inch thick, with a 1-inch web on each side at top and bottom, and a fillet ½ inch square on each side along the centre of the rafter for the upper sashes to slide on. The rafters are each leaded down by two strong iron pins at each end to the stone coping of the front and back walls, on which they rest. They are made thicker at the lower end of the upper groove to prevent the upper sash from sliding down beyond its proper travel, the upper half of each sash being made loose, to slide downwards. The form of the sash-bars is shown in section in figs. 18 and 20, Plate XXI. They are of wood, 2 inches deep by 1 inch thick in the centre. The glass work of each pit consists of 23 sashes, each sash consisting of five panes in width, and each pane measuring 6¾ inches from centre to centre of sash-bars. The bottom plate of each sash is 6 inches by 2 inches in section. The top and centre plates are each 4 inches by 2 inches, and the sides are of 2-inch square timber, finished sizes. Each sash is divided into upper and lower halves, and is 3 feet 1¾ inches wide. The glass is of the same kind precisely as is used for the range of vineries and peach-houses.

"To facilitate the opening and closing of the sashes from the outside a stone platform runs along the back of each range of pits. It is supported on a brick arch, 3 feet wide behind the front range, and 2½ feet wide behind the back range, in each case 7 feet high at the under side of the crown above the footings. The springings of these arches are from the back wall of the pit on one side, and from brick pillars, 9 inches thick by 2 feet wide, on the other, having 2½ feet arched spaces between them. The space under this arch is lighted through windows *d*, each 12 inches square, as shown in section, fig. 21, Plate XXI. The arched spaces lead into another arched cellar, or vault, at the back of each pit, 2½ feet wide by 4½ feet high from the under side of the crown to the floor, which is laid on the footing-course. The back of these cellars is of 9-inch brickwork. They form convenient receptacles for pots not in use, and for gardening utensils. In the tallest cellar, against the back wall of each pit, a shelf is fixed all along, 6 feet high above the floor, and supported on iron brackets, to hold small pots containing heaths and similar plants. These arched passages (marked *b* on the section, fig. 21, Plate XXI.) are approached by a flight of steps at each end of the range, shown in dotted lines in the section.

"A wooden shelf, for melons in pots, 15 inches wide, is supported on iron brackets driven into the back wall of each pinery, 18 inches below the stone coping. The floors of the back walks and of the arched vaults are of brick set on edge.

"Centrally situated with respect to these pineries are the underground vaults, which contain the boilers and fuel. These are shown in basement plan, fig. 18. The whole of the space, 27½ feet long by 11½ feet wide, inside measure, between the ends of the pits, is appropriated to the stairs and fuel, except a space at the back, of 6 feet by 11½ feet, which is appropriated to pots and garden stores. There are four fuel-chambers, the two in the front being each 9 feet by 2 feet 6 inches, and those in the rear each 5 feet by 2 feet 6 inches. The walls forming these chambers are all of 9-inch brickwork, and they are arched over at the top, below the external ground level, so as to leave an uninterrupted passage between the ends of the pits. A clear space of 6¼ feet is left between the front and back fuel-chambers for convenience of stoking the boilers. There is a flight of 11 steps, 21 inches wide, on each side of the front fuel-chambers between them and the ends of the front pits, by which access is obtained to the stoking-chamber. The third step from the bottom, on each side, is 2 feet in the tread, forming a landing; the other being 1 foot in the tread. From these landings a flight of steps on each side leads up to the back walk along the front row of pineries. A circular opening, 12 inches in diameter, is formed in the brick arch over each fuel-chamber, and provided with a stone kerb, rebated to receive a cast-iron cover, ½ inch thick, for supply of fuel. A similar circular opening, 18 inches in diameter, is formed in the brick arch over the stoking-chamber, with stone kerb rebated to receive a cast-iron grating, ½ inch thick, for supply of air. The boilers, four in number—one for each pinery—are fixed under the spaces between the front and back ranges of pineries. They are each 3½ feet long by 2½ feet wide, of the arched or saddle form, with 6-inch water-space, made of wrought-iron plates ¼ inch thick. The fire-gate of each boiler is 30 inches long by 18 inches wide. The arrangement of the pipes is shown in plan, fig. 17, and in section in Plate XXI., fig. 21. Fig. 17 represents one-half of the pineries, with their heating apparatus, the arrangement being precisely similar in the other half. A cast-iron pipe, 4 inches internal diameter, proceeds from the front boiler to the front of the front pinery, and there turns by an elbow along the gutter in which it is fixed, at such a height as to be always half immersed in water. At the further end it turns by means of two elbows into the chamber before spoken of beneath the pit. At the end of this chamber it divides into two branches by a double outlet-pipe, having two 6-inch sockets, one for each outlet, by which means each branch is enlarged to 6 inches in diameter. The two 6-inch branches run parallel to and level with each other to the boiler end of the pit, where another and similar outlet reduces them into one 4-inch pipe, which returns, by means of two elbows, into the boiler.

"The arrangement of pipes in the back pinery is precisely similar, except that the chamber under the pit contains three instead of two parallel rows of 6-inch pipe. The 4-inch pipe proceeds along the gutter as in the front pinery, and enters the chamber beneath the pit by an elbow provided with a 6-inch socket. From this socket a 6-inch pipe proceeds all along the chamber to the further or boiler end, and is then turned back again by a double bend to the other end, and thence by another double bend back to the boiler end, at which a similar 4-inch elbow, with a 6-inch socket, returns it by two 4-inch elbows into its boiler.

"At the places where the pipes pass through the side wall of the gutter, they are passed through and cemented by iron cement to a socket cast on a plate which is built into the brickwork, which preserves the side of the gutter water-tight.

"By these arrangements an ample command of the highest temperature necessary for pines is obtained. Evaporation, and consequently moisture of the atmosphere, is obtained to any extent by means of the front gutter. The 6-inch pipes beneath the pit supply an abundant bottom heat, which, by means of the openings in their back walk and the hollow front wall, is afterwards communicated to the atmosphere of the pineries. By this means also a salutary movement is imparted to the whole atmosphere, which may be further moistened if required by turning water, by suitable pipes and cocks, into the chambers under the pits, where the heat of the 6-inch pipes will evaporate it, and produce a moist bottom heat, which will produce its effect on the compost, or soil, in the pits through the openings in the brick arches which form the coverings of the chambers.

"The smoke from all the boilers, both of the hot-houses and pits, is conveyed by under-ground flues to a large chimney, situated at a distance in the rear of the pits, by which means all appearance of smoke about the hot-houses, as well as the disfigurement produced by chimneys in the back walls, is entirely avoided.

"The whole of the arrangements about these ranges of hot-houses and pits are of the most complete and perfect description. They have been for some years in practical and satisfactory operation, and the beneficial results obtained are amply demonstrated in the size and quality of the fruit produced. The size of the structures is sufficient for the supply of a nobleman's mansion. The compact arrangement of the boilers which heat the pits is one which may be used to great advantage in every large garden requiring parallel ranges of forcing-pits."

32. Points to be considered in the Arrangement and Construction of Garden Buildings—Light, Ventilation, Heating.

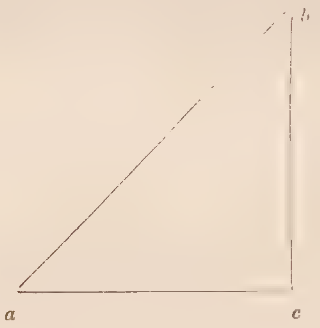
33. The importance of light need not be here dilated upon; without a due supply of it vegetable life languishes and the plants are never developed to their full proportions. Important as a supply of pure *air* is to plants, it is doubtful whether it is not *less* so than a supply of light. By the deficiency of pure air the plant is only deprived of its food; while by that of light it is entirely deprived of its proper function, so that it cannot assimilate the food which is presented it. It is worthy of note that the light exercises its best influence upon the plants when they are near the glass; beyond a certain distance—and this regulated by circumstances—the rays of light have no influence upon the vegetative powers of the plant. This arises from the refraction of the rays passing through the glass. Leaving the glass at a different angle from that at which it entered, the ray of light is correspondingly weakened. "In building a green-house or conservatory, then, light ought to form the first point of importance, as success in plant life is entirely subservient to it; and we know full well from experience that no skill, however perfect, and no attention, however zealous, will compensate for a deficiency of light. Indeed, no contingent or permanent advantage can justify to the mind of the experienced gardener the adoption of one inch of opaque material in the sides or roof of a horticultural building; and no part of the structure, from the side shelves and upwards, should be rendered opaque that can be consistently covered with a material capable of admitting the rays of light. For pillars, and other appendages of strength, the material ought to be as light as consistent with strength and durability in the structure."

34. "Light," says a writer in a horticultural journal, "light to a certain extent follows the same laws as heat. It is received by radiation from the sun, reflected by smooth surfaces, transmitted and refracted by transparent substances, such as water and glass, concentrated by reflection from concave surfaces, and dispersed by reflection from surfaces that are convex. Light, however, differs from heat in the impossibility of retaining it after the absence of the sun; whereas heat can be retained by enclosing heated bodies in non-conducting mediums, and by reflecting it back to the surfaces from which it is radiated. The radiation of light is greatest when the radiating rays strike the surface at a right angle, and the least when the angle is most oblique, because in the former case the rays are reflected on every side, and consequently the surrounding objects are illuminated proportionably, and in the latter case the greater number of rays pass off at one side, and illuminate less effectively the surrounding medium. The reflected rays are always returned from the surface on which they radiate at an angle equal to the angle of incidence; if the reflecting surface be a plane, the reflected

rays will be parallel to each other; if the surface be convex, they will be divergent, and consequently dispersed; and if it is concave, they will be convergent, and hence concentrated. Smooth and shining surfaces reflect most light, and rough and dark surfaces least; and with respect to colour, white reflects almost all the rays of light which fall upon it, and black absorbs them all. When light falls on a transparent medium, a portion of the rays is transmitted through it, and a portion is reflected from its surface. The latter portion follows the same laws as the light which is reflected from opaque surfaces; and the portion which passes through it is refracted—that is, it leaves the transparent medium at a different angle from that in which it fell upon it, and by this change the light is also weakened, so as, at a very short distance from the surface of the transmitting medium—as of glass, for example—to be dispersed and transfused in the atmosphere, in which state, in hot-houses, it has no longer the same power on the vital energies of plants. We are not aware that the cause of insufficiency of light, after it has passed through glass and reached a certain distance, has been fully explained; but the fact is well known to gardeners, who, in hot-houses, invariably place the plants they wish to thrive best at the shortest distance from the glass. As the quantity of light which passes through glass at the roof of hot-houses is, all other circumstances being the same, greatest when the plane of the roof is at right angles to the plane of the sun's rays, so the slope of the roof is, or ought to be, adjusted to the direction of the sun's rays at that season of the year when its light is most wanted. As in houses for early forcing, the greatest deficiency of solar light is in the winter season, when the sun is low, so the roofs of such houses are made steep in order that the sun's rays may be received at a larger angle. Summer forcing-houses, on the other hand, have less steep roofs, so as to receive most benefit from the sun in April, May, and June, when forced fruits are ripening. A green-house in which no fruit is ripened, but in which abundance of light is required all the year, has commonly perpendicular glass to receive a maximum of light during winter, and a sloping roof of glass, at an angle of 45°, which is found favourable for the admission of light at every season, as well as for throwing off rain."

35. We have seen that the rays of light sent through glass are passed *from* it at a different *angle* from that at which they *entered* it. M. Bouquer has shown that if a thousand rays fall *perpendicularly* upon the best crown glass, the whole of them will, with the exception of one-fortieth part, pass through; but if they fall upon the same glass at an *angle* of 75°, two hundred and ninety-nine of the rays will be reflected. The importance, then, of the angle or slope of the roof will thus be observed. This is a point which has given rise to much discussion. The angle considered generally best is 45°, and it is worth noting, that where the height of the perpendicular is equal to the width of the house, the angle resulting is always 45°. It is needless here to go into the discussion on this point of the "angle of inclination," for after all that has been said about it, as Mr. C. M'Intosh shrewdly remarks in the "Book of the Garden," vol. i., p. 139, "it is not at all strange that no particular angle should be fixed upon as the true one, because that which would be a very proper angle for a peach-house, for instance, at Torquay, would be a bad one at Thurso, the difference of latitude being considerable. That for early forcing anywhere, would be improper for a late forcing-house in the same latitude. It therefore follows that the angle of elevation, if of the importance some attach to it, and which, to a certain extent, we do not deny, must be made to correspond with the latitude the house is placed in, and also to suit the purpose for which it is intended." The following rules to "find the angle of roofs of hot-houses," and "to determine the angle of glass roofs," will be useful here:—"By means of a Gunter's scale and a pair of compasses the pitch or elevation of roofs may be found easily as follows:—Draw a horizontal line, and from the end of this another at right angles, by a square or otherwise; on the former set off as many equal parts, say half inches, as the house is feet in width, between where the outer side of the rafter touches the front wall-plate and the back wall; and on the other as many of such parts as the back wall is feet in height, measuring from a point on a level with the front wall-plate to the under side of the rafter at top. A line drawn between the points marking the above measures will form the slanting side of a triangle, corresponding with the pitch or elevation of the roof. It only remains to ascertain the number of degrees which the angle contains. With the distance of 60° form a *line of chords*, marked *cho.* on Gunter's scale; place one foot of the compasses in the angular point, and with the other describe an arc, intersecting the lines representing the base and roof; the distance between these lines at the points of intersection by this arc will extend from the beginning of the line of chords to the number of degrees which the angle contains, or, in other words, to the number of degrees of elevation. Or a simple way is the following. Describe the triangle *a b c*, on which let *a c* represent the width, and *b c* the height of the back wall above the front wall-plate; then place the instrument called a protractor, with its middle line at *a*, and the line *a b* will intersect on the protractor the angle required." To determine the angle of a roof Mr. Wilkinson has the following:—"The angle contained between the back wall of the forcing-house and the inclined plane of the glass roof, always equals the sun's altitude when its rays fall perpendicularly on that plane, provided that the inclination of the plane to the horizon be at an angle not less than 28° 2′, nor greater than 75°. Within the above limits the sun's rays are perpendicular twice in the year—once in going to, and once in returning from, the tropic. Hence, then, having determined in what season we wish to have the most powerful effects from the sun, we may construct our houses accordingly by the following rule:—Make the angle contained between the back wall of the house and its roof equal to the complement of the latitude of the place, less or more, the sun's declination for that day on which we wish its rays to fall perpendicularly. From the vernal to the autumnal equinox the declination is to be added, and the contrary. Thus, to apply those principles to the slope of roof recommended by Knight for ripening grapes in July, say, at London, we have

Latitude of London,	51° 29′
Sun's declination on the 21st of July,	17° 31′
Or 34° nearly,	33° 98′



36. Ventilation.—It is difficult to overrate the importance of this essential in hot-house construction. For long, little or no attention was paid to it; when attended to at all, it was mainly with the view of keeping down any excess of temperature; the importance of a *change of air* in the building, or the establishment of a current through it being rarely thought of. We regret to say that this point is still too often overlooked; its importance, however, will be gathered from

the following remarks, by the well-known authority on horticultural matters—Dr. Lindley—extracted from the "Gardener's Chronicle," of which he has been long the valued and esteemed editor:—"When a man builds a forcing-house he settles carefully the slope of the roof, the nature and direction of the heating-apparatus, the material for his shelves and floors, the quality of his glass, the size of the squares, and the depth of their laps. Whether the door shall be at the end or side, and the whereabouts of the stake-hole, are other points of grave deliberation. How, then, are we to account for the almost universal neglect of the most important part of all—THE VENTILATION?

"But no; we wrong the builders of forcing-houses; they do not neglect ventilation; on the contrary, they provide for it copiously. They make the roof-sashes slide and the side windows unfold, and the doorway alone administers no inconsiderable doses of wind. In fact, the ventilation—if by that term is meant the *letting-in of wind*—is in no ways deficient. But unfortunately this is not precisely what plants require. They want in draughts neither of hot, dry air in the dog-days, nor of ice-cold breezes in the winter. Both hot and cold air act like water, the one scalds, the other freezes. It is because of the danger of such ventilation as this that gardeners have concluded that a close, moist atmosphere is indispensable to vines when in flower—a singular mistake, which the author of this article has disposed of some years ago."

"If we did not hate new words," says the same high authority, "we should be half inclined to expunge ventilation from the language of gardening, and to substitute zephyration, or some such gentle epithet. We shall, however, content ourselves with distinguishing ventilation from *aëration*, the latter a legitimate word, in actual use, defining *ventilation* as the process of letting the external air at once into a forcing-house, and aëration as the act of keeping the atmosphere of a forcing-house in motion by currents of warmed fresh air. The importance of *aëration* cannot be over-estimated. It is the one thing which now requires to be secured, in order to render our artificial climates natural. A man's reason, indeed, must tell him that a plant condemned to pass its life in a still atmosphere is like nothing so much as a criminal set fast in an everlasting pillory. In order to secure motion in the vegetable kingdom, currents of air are made to do the work of the muscles, limbs, and volition of animals. It is not at all improbable that, in addition to the mechanical effects of motion in assisting the propulsion of the sap, it may be important that the stratum of air in contact with the leaves of plants should be incessantly shifted, in order to enable them to procure an adequate supply of food; for we find that water in motion feeds them better than that which is stagnant. Leaves are continually abstracting from the air the very minute quantity of carbonic acid which it contains. When the air moves quickly over their surface fresh supplies of that food are incessantly presented to it, and the operation of abstraction may be facilitated; while, on the contrary, if the air is stagnant, the absorption of carbonic acid may be much slower.

"Perspiration is another vegetable function which must be maintained in healthy action. The quantity of water that flies off from the surface of a plant will, *cœteris paribus*, be determined by the rapidity of the motion of air passing over its surface. In an absolutely still air, perspiration will be reduced to its minimum, and will increase within certain limits in proportion to the quickness with which the air sweeps over it." "If the motion of air is thus favourable to the two great operations of feeding and perspiration, we shall find that it is equally needed day and night, for perspiration goes on principally during daylight, and feeding in the hours of darkness. A good system of aëration *must then be constantly in action.* How to secure that is the great horticultural problem which now remains to be solved."

37. We have gone so fully into the details of ventilation, theoretically and practically considered, in another Essay in the present work, that little remains here to be said in connection with it. The mechanism of ventilation, as applied to garden structures, is remarkable for its various forms; indeed, to describe, and describe but briefly, all the apparatus introduced from time to time during the last twenty years, would be a task involving more labour and space than we deem them worthy of. The following description of a method illustrated in Plate XVII. will, in connection with what has been given in our Essay on Heating and Ventilation, be all that is requisite—noting here further, that the description of a recently-introduced mode of ventilating will be found described in the department of our paper entitled "Recent Improvements in Garden Structures."

38. In figs. 7, 8, and 9, Plate XVII., will be found illustrated the mode of ventilation adopted in buildings designed by Mr. Halliday, gardener-in-chief to the Earl of Mansfield, and erected by Messrs. Shanks & Son of Arbroath. The fresh air is admitted through openings in the front wall of the building, these being provided with hinged shutters, *a a*, fig. 9, Plate XVII. These are opened and closed by means of a simple arrangement of levers and shaft, as shown in fig. 8. A lying shaft *a* runs along the whole length of building, and is worked by means of a handle or lever, situated at a convenient place. A lever *b* is connected with this shaft, and this again with a moveable rod *c*; to this is attached, at intervals corresponding with the distance of centre of valves or shutters *a a*, fig. 9, levers *c*, which are hinged or jointed to the shutters or valves *e*, these being jointed at their upper sides, as shown in the drawing. A modification of this plan is shown at fig. 7, where the shutters or valves *a*, working in the apertures through which the fresh air is admitted to the building, are worked by levers *b b*, through the intervention of the handle *c*. This works in the guide *d*, and by moving the handle in this guide up or down, the shutters *a* are opened or closed correspondingly. The shaft to which the lever *b* is attached runs along the whole length of building.

39. The heated or used air is allowed to pass from these buildings in one of two ways—either by that illustrated in fig. 7, or that in fig. 9, Plate XVII. In the method illustrated in fig. 9, the air passes from apertures *a a* made in the upper part of the back wall. Shutters or valves *b b* are provided in front of these apertures, and, to one or more of these, racks *c c* are provided, into which gear pinions *d*. These pinions *d* are moved by the upright shaft *e e*, which again is had under control by the horizontal lever handle *f*, by the turning of which, in a right or left hand direction, the shutter *b* is made to close or open the aperture *a*. The other method is shown in fig. 7. In this case the aperture is closed by the valve *a* oscillating in a stud at its centre, and controlled by the levers *b b b′*. The lever *b′* is raised or lowered by means of the vertical shaft *c c*, worked by the handle-wheel *d*. The lower end of the shaft *c c* is screwed, and works in the nut of the bracket *e e* attached to the back wall of building. By turning the wheel *d* to the right or left, the vertical shaft *c c* is raised or lowered, and the valve *a* closed or opened accordingly.

40. Heating.—We have so fully gone into all the details of this most important subject, in the companion Essay on "Warming, Ventilation, and Artificial Lighting," that we have here comparatively little to say in connection with it. There are various modes of heating hot-houses in use—hot-air stoves, steam, and hot water. Of these, by far the most economical and easily managed is the hot-water system. On this the following remarks, from a paper read before the

"Horticultural Society of London" by J. Rogers, Esq., will be useful:—

"It is a great desideratum with gardeners—as far, at least, as my experience goes—to get up heat in a short time; and their ordinary test of the excellence of a hot-water apparatus is, how speedily they can get the water to boil. Where an apparatus is properly constructed, this can seldom be effected without a most extravagant waste of fuel. The water in a hot-water apparatus, constructed on the most perfect principles, will take as many hours to heat to the boiling-point as the pipes which contain it are inches in diameter, and it will also cool in the same ratio. Four-inch pipes will accordingly take four hours to reach the temperature of 200°; and they can be heated to the boiling-point in one hour only by the consumption of four times as much fuel as would suffice, if properly applied; or, in fact, allowing for the waste of heat by the chimney—which increases under such circumstances very rapidly—five or six times as much fuel as is really necessary will be consumed by a gardener zealous of the honour of his apparatus. It is, of course, possible, by having a furnace and boiler excessively large in proportion to the pipes, to construct an apparatus with 4-inch pipes which shall boil in an hour; but the necessary consequences will be, that such a furnace would burn during every hour of the night four times as much fuel as can possibly be effective in heating the building to which it is applied.

"If a house is to be heated rapidly, the pipes should be of the smallest diameter which is consistent with a free circulation; but it must be borne in mind that such pipes will also cool with equal rapidity; and if the heat is to be maintained through the night, the furnace must be so constructed as to contain a large quantity of fuel, but only to allow of a very slow consumption. Now, such a furnace, though theoretically very easy, and practically not very difficult of construction, requires an almost scientific nicety of management not to be expected from common gardeners. There are, moreover, several objections to small pipes, one of the most material of which is this—That the motion of water within them being retarded by friction in a much larger degree than in large pipes, they can never be brought to so high a mean temperature. So that under similar circumstances of pressure, &c., 200 feet of 1-inch pipe could never be made to produce the same effect as 50 feet of 4-inch pipe, though their surfaces would be nearly equal.

"A little consideration will enable us to determine whether such rapid communication of heat be really essential to the efficiency of a heating apparatus. In hot-houses, where permanent heat is required, it is evidently unnecessary. The only place where it may be desired is in buildings where occasional heat only is required. The real desideratum is a furnace so constructed that it shall contain fuel enough to supply the pipes with as much heat as they can radiate during the night, and which may be depended upon for burning steadily and perfectly whatever fuel is put into it, not with that accurate precision requisite where the temperature of the house depends upon the exact amount of combustion per hour, but sufficiently slow to allow the water to absorb the greatest possible portion of the heat generated. With such an apparatus, the fire being once effectually lighted, the gardener need be under no apprehension that the heat during the night will prove insufficient, though it may several hours before the pipes attain their maximum temperature.

"I have dwelt somewhat at large on this point, because it is one on which much mistake exists; and under this misapprehension the best apparatus may be condemned as defective, and a very imperfect one preferred and adopted in its stead—that which is commonly adopted as a criterion of excellence being really a proof of defective construction.

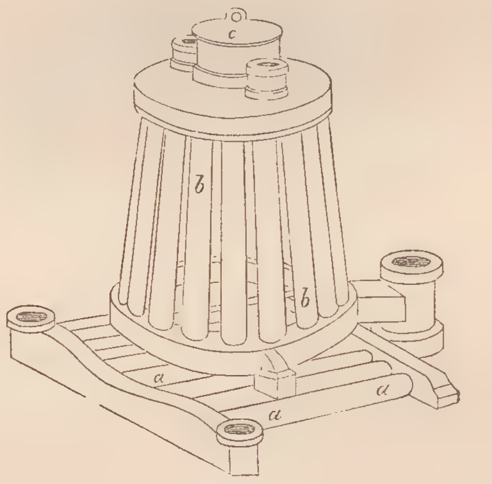
"There can be, on the whole, no doubt that 3-inch or 4-inch pipes are exceedingly preferable to smaller ones, where economy of fuel and uniform adjustment of the temperature for several hours are the primary objects. Where ornament or great economy of space is important, and economy of fuel is not much considered, smaller pipes may be employed; but where rigid heating is considered essential, I believe it will be found best to have recourse to the old expedient of brick flues; and their attendant inconveniences must be considered as the price paid for this advantage, real or imaginary. . . . .

"The next point which requires notice is the expediency of heating several houses from the same boiler. Now, to this arrangement there is not the slightest objection, provided the same number or extent of houses is always to be heated at the same time—that is to say, several hot-houses, all of which require permanent heat, but different temperatures, may be advantageously heated from one boiler. In like manner a range of green-houses, always requiring heat at the same time to exclude frost, may be worked from one boiler, though different degrees of heat are required in them; and even if one of those sometimes requires, as it probably would, a slight degree of heat when the others require none, this may be arranged without difficulty or inconvenience. But serious inconveniences will arise from any attempt to heat two buildings, in one of which occasional, and in the other permanent, heat is required; and this inconvenience will be great in proportion to the size of the buildings, especially if, as is generally the case, the hot-house is small, and the green-house, or pits, more extensive. The same inconvenience will also be felt if two vineries, one to be forced at a later period than the other, are to be heated from one boiler. The reason is briefly this, that the capacity of the furnace for fuel, the area of its bars or its consuming power, and the boiler surface or absorbing power, are all calculated with reference to a certain quantity of pipe; by urging the fire to the utmost power which is consistent with a proper duration of its heat, the pipes to which it is ordinarily attached are heated to their maximum, and the maximum heat is produced as required in the building. If, at this time, an additional extent of duty is laid on the boiler by opening the sluices which connect it with the pipes of a green-house or pits, the temperature of the ordinary service pipes is reduced, and the hot-house receives a diminished quantity of heat just when it requires most. On the other hand, if the common boiler be constructed of a size and power adequate to the double service, it will, when applied to the hot-house only, constantly over-heat it; and this effect can be prevented only by throwing open the furnace door, and allowing the fuel to burn to waste; for, be it observed, it is the area of the furnace bars which regulates the consumption of fuel. It is true that by means of dampers and skilful management some remedy may be found for those evils, but nevertheless they will exist to a greater or less extent, and the arrangement above mentioned should never be willingly adopted.

"The different temperature of stoves to be heated from the same boiler may be regulated with the most philosophic accuracy, by allotting to each house quantities of pipe bearing a different proportion to their respective surfaces of glass. The difference thus established will be maintained for all temperatures, unless accidental circumstances of exposure to wind or imperfect glazing should cause a variation, and the general heat of all may be regulated by attention to one fire."

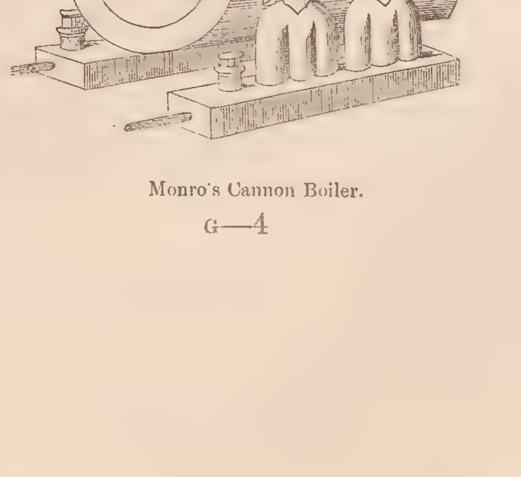
41. The forms of *boilers* are very numerous. In Plate XXXIII. we give, in fig. 10, a vertical section of Walker's Hot-water Boiler. In fig. 19 we give a sketch of the Jointless Tubular Boiler, made by Henry Ormson of Stanley Bridge, King's Road, Chelsea, London. In fig. 20 we illustrate Monro's Cannon Boiler; and in fig. 21, simpler forms

Fig. 19.



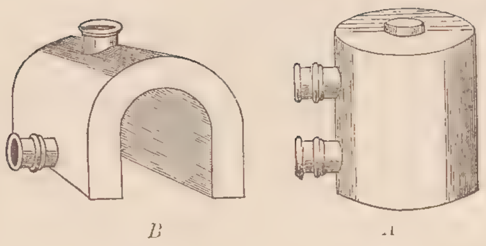
Ormson's Jointless Tubular Boiler.

Fig. 20.



Monro's Cannon Boiler.

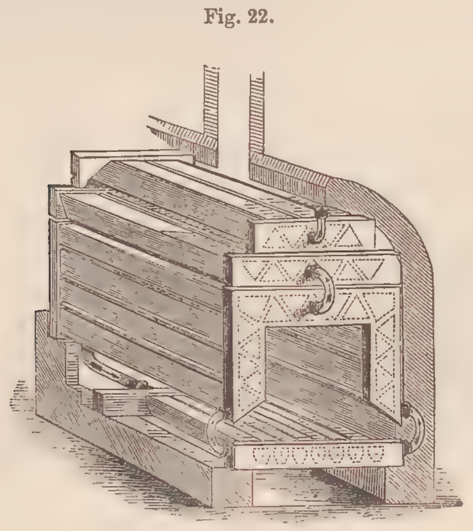
Fig. 21.



(*A*) Cylinder Boiler; (*B*) Saddle Boiler.

suitable for small houses, as *A* the Cylinder Boiler, and *B* the Saddle Boiler. The "Cannon," "Cylinder," and "Saddle," boilers are all made by Mr. Jones, Hot-water Apparatus Maker, 6 Bankside, Southwark, London. In fig. 22 we give a sketch of the Triangular Tubular Boiler, patented and manufactured by Mr. Messenger, Horticultural Builder, Loughborough.

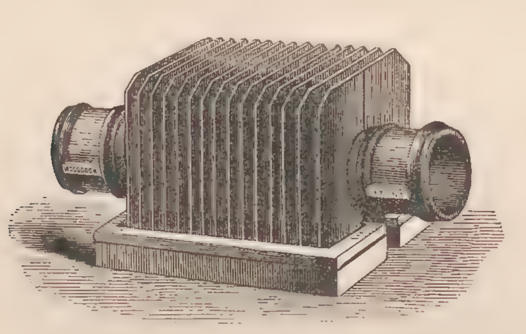
Fig. 22.



Messenger's Triangular Tubular Boiler.

42. In place of having pipes for heating the interior of hot-houses, ranges of heating surfaces may be adopted as described in pars. 42, 43, Essay on Warming. Fig. 23 is a sketch of Gurney's Battery-heater, adapted for Conservatories.

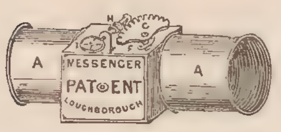
Fig. 23.



Gurney's Battery-heater for Conservatories.

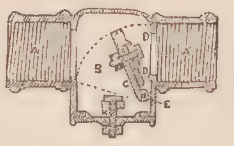
43. Fittings of Pipes, &c.—In Plate XVII. will be found sketches of various fittings, as manufactured by Messrs. Shanks of Arbroath. In fig. 24 we give an elevation of the water valve invented by Mr. Messenger of Loughborough, and in fig. 25 a section. In this valve—which is easily regulated by the screw and rack—the full size of the bore of the pipe is given when the valve is open—an advantage not obtainable in the ordinary stop-cock. In fig. 10, Plate XVII., we give the section of a valve made by Messrs. Wood & Tomlinson, 27 Oxford Street, Manchester. The general way by which moisture is supplied to the interior of hot-houses requiring it —as vineries—is by having a trough cast on one of the lengths of heating-pipes; in this a supply of water is placed, which gradually gets warm and passes off vapour. A form of moisture-trough is shown in Plate XVII. This system has its disadvantages, which are entirely obviated by the plan introduced by Mr. Thompson, head gardener at Dalkeith Palace gardens, and made by the Messrs. Shanks of Arbroath. The troughs in Mr. Thompson's plans are made altogether distinct and separate from the heating-pipes. They are set to the level of the water height in the boiler, and made to communicate with the hot-water pipes by means of small connection-pipes, furnished with stop-cocks. When moisture is wanted, the stop-cock connected with the flow-pipe is opened, and the water from the pipes and boiler immediately flows into the trough, and is sustained at the same level as the water in the boiler. The heated water flows along the trough, and descends at its other extremity into the return-pipe. A gentle current of hot water is thus kept up in the trough, yielding a copious, yet almost imperceptible, supply of vapour. In the old moisture-trough, if the pipes are hot, and water suddenly admitted to the troughs, a cloud of steam is instantly passed off, which has by no means such a beneficial influence on the plants as the gentle vapour continuously passed off by the means noted above.

Fig. 24.



Elevation of Messenger's Water Valve.

Fig. 25.



Section of Water Valve.

44. *Calculations connected with the Ventilating and Heating Garden Structures.*—In the companion Essay on Warming and Ventilation, will be found ample instructions on these heads. As supplementary, however, to what we have there given, we extract from Mr. Hood's valuable treatise on "Warming Buildings by Hot Water"—(London: Whittaker; p. 119)—the following table, showing the quantity of pipe 4 inches diameter which will heat 1,000 cubic feet of air per minute any required number of degrees, the temperature of the pipe being 200° Fahrenheit. Mr. Hood begins his table with the heat of 45°; we commence at 60°, with the external temperature at 32°.

Temperature of External air.	Temperature at which the room is to be kept.						
Fah. Scale.	60°	65°	70°	75°	80°	85°	90°
32°	112	137	164	193	225	259	296
34	104	129	155	184	215	249	286
36	96	120	147	175	206	239	276
38	88	112	138	166	196	230	266
40	80	104	129	157	187	210	255
42	72	95	121	148	178	200	245
44	64	87	112	139	168	190	235
46	56	79	103	130	159	181	225
48	48	70	95	121	150	171	214
50	40	62	87	112	140	161	204
52	32	54	77	103	131	151	194

Find, "in the first column, the temperature corresponding to that of the external air, and in one of the other columns find the temperature of the room; then in this latter column, and on the line which corresponds with the external atmosphere, the required number of feet of pipe will be found." Mr. Hood, in his work (p. 121), gives also a table showing the quantity of coal used per hour to heat 100 feet of pipe of different sizes:—

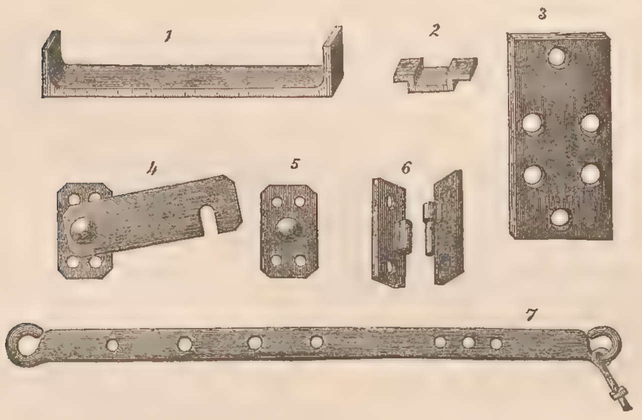
Diameter of pipe in inches.	Difference between the temperature of the pipe and the room in degrees of Fahrenheit.														
	150	145	140	135	130	125	120	115	110	105	100	95	90	85	80
4	1·7	4·5	4·4	4·2	4·1	3·9	3·7	3·6	3·4	3·2	3·1	2·9	2·8	2·6	2·5
3	3·5	3·4	3·3	3·1	3·0	2·9	2·8	2·7	2·5	2·4	2·3	2·2	2·1	2·0	1·8
2	2·3	2·2	2·2	2·1	2·0	1·9	1·8	1·8	1·7	1·6	1·5	1·4	1·4	1·3	1·2
1	1·1	1·1	1·1	1·0	1·0	·9	·9	·9	·9	·8	·7	·7	·7	·6	·6

In this table "the temperature of the pipe is assumed to be 200°; thus knowing the temperature of the room, if we take the difference between the temperature of the pipe and that of the room, by looking in the table for the corresponding temperature, we shall find under it the number of pounds weight of coal which will be required per hour for every 100 feet in length of pipe in order to maintain the stated temperature."

45. Recent Improvements in Garden Structures.—We propose, in this department, very briefly to describe some of the most recent improvements introduced in the construction of hot-houses, &c., &c. And first, in point of earliest date, if not of greatest importance, is the system patented by Sir Joseph Paxton. Of the arrangement of houses in this plan we have already given illustrations in a former part of this Essay. We now give the details of the construction, for the matter and illustrations of which we are indebted to Mr. Herman, the intelligent agent for the system (7 Pall Mall East, London).

46. In fig. 26, in diagrams 1 to 7, we give the details of iron work necessary to erect the houses on this system, and the following is the description of the approved mode of erection recommended by the patentee:—"First make a setting-out rod by fastening long stripes of laths together with screws the full length of the house intended to be erected; upon this rod, laid upon the ground, mark off the width of each sash in its proper position, measuring the width of the first from one end of the rod (the sashes will either be 4 feet 7 inches or 4 feet 8 inches wide, according to their strength), then allow a space the length of the gauge-bar (fig. 1, 26), which connects the first sash with the second; the space between the sashes governed by this bar is 9 inches. Afterwards mark off the width of the second sash and the second space for the gauge-bar, and so proceed to the end of the range.

Fig. 26.

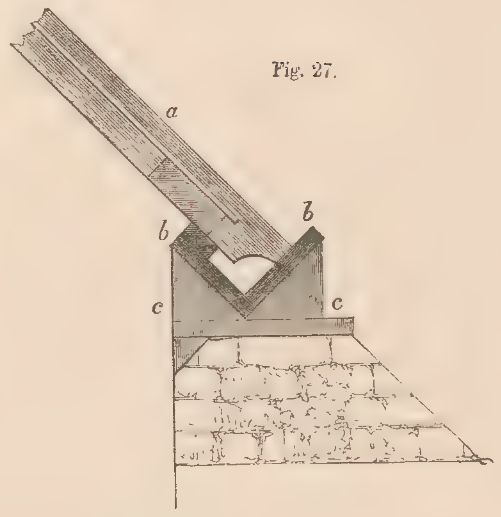


Details of iron work of Paxton's System of Hot-house Construction.

"Having thus marked on the setting-out rod the precise position of each sash and each space for ventilation to the whole length of the house, proceed to mark on the ground the places for each of the piers, taking the ends of the rod and the middles of the spaces as centres. Each pier, if built of bricks, should be 14 inches square, and at such a distance from the back wall as the arranged span of the house determines; the piers so placed will always come under the side styles of the sashes. When piers are required higher than 2 feet, and when the sashes are 14 or 16 feet long, it is better to build them 14 inches by 18 inches, the latter measure from the inside of the house outwards. When piers are built of stone or concrete, this size need not be increased more than the nature of the materials demands to afford sufficient strength. Fig. 27 represents the section of a pier of rough stone, or concrete, the inside being kept perpendicular and the outside sloping, so as to form an abutment to meet the thrust of the sashes.

"When the piers are built and sufficiently set, fix on the saddles (*c c*, fig. 27); cement will be required if the piers are of brick or stone, but if the piers are of concrete, lime mortar; the saddle-board *c c* being always placed quite level. A fall, just sufficient to allow the water from the roof to run to one end of the gutter, and be then discharged, must be allowed in the length of the house.

Fig. 27.



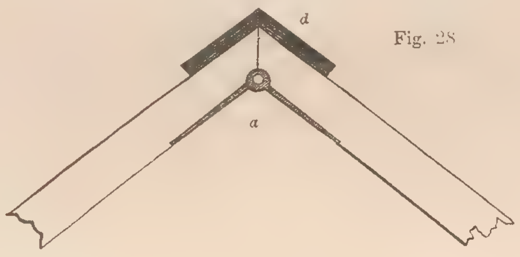
Footing for House Rafters on Paxton's System.

"In the absence of a plan, the distance of the piers from the back wall of a lean-to house may be found by measuring across the door and the base of the end sashes, from the back to the front, terminating under the roof-sash above the point *b*, fig. 27, and if a span-roof, a similar measurement will give the span of the house. The piers on both sides of a span are similar, and must be precisely opposite to each other, at right angles to the path-line of the house. And when a plan of the end is sent, it is advisable to verify it by measuring the actual sashes as above.

"The saddles being properly fixed, place in the water-gutter, *b b*, fig. 27; this runs continuously the whole length of the structure, each length of gutter meeting and joining in one or other of the saddles. In this gutter the lower ends, or horns, of the sashes are placed, *a*, fig. 8.

"In a lean-to house the top of the sash is simply leaned against the wall, and, except in large sizes, does not require any plate for support, but in a span-roof the sashes support each other. To effect this, each pair is connected by two hinges let into the styles at the top, as *a*, fig. 28, and by erecting two sashes thus hinged, and fitting them over the end sashes, the position of the gutter, saddles, and piers on the other side of the span is accurately determined.

Fig. 28



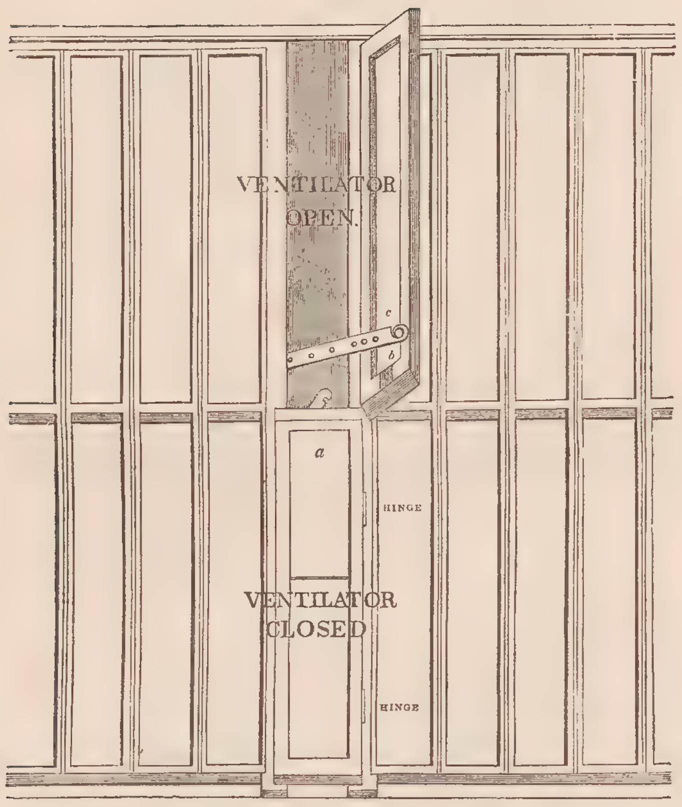
Junction of Rafters on Paxton's System.

"The first sash of a lean-to, or a pair of sashes of a span, being fixed, the second pair is raised in like manner, and then united on each side by two gauge-bars, diagram 1, fig. 26, each of which slides into two staples, diagram 2, fig. 26, screwed on the sides of the styles at about 2 feet from the top, and the same distance from the bottom of the sashes, and this is repeated betwixt every pair of sashes until the whole of the roof is fixed.

"The ventilators covering these 9-inch spaces are hinged to the upper edge of the left-hand side styles of the sashes, and shut down one inch over the right-hand styles of the adjoining sashes, fig. 29, two hinges, diagram 6, fig. 26, being placed to each half ventilator, the hooks, diagram 6, fig. 26, are screwed on the sash-styles, and the eyes on the edge of each ventilator.

"The catch, diagram 4, fig. 26, is screwed on the under side of the upper rail of the lower ventilator, *a*, fig. 29, and the catch-bolt, fig. 5, on the lower rail of the upper ventilator, *b*, fig. 29, so that the two portions of the ventilator, when shut

Fig. 29.



Ventilator on Paxton's System.

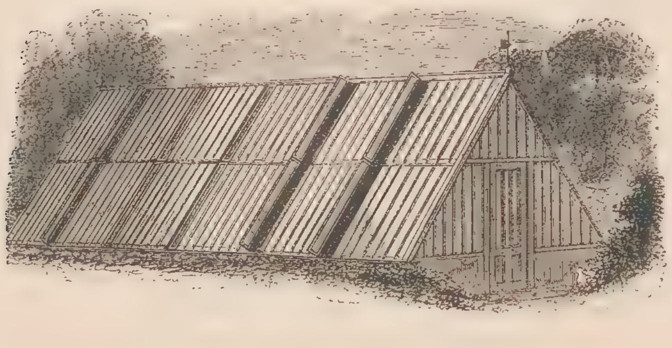
down, may be fastened together, and the stay, diagram 7, fig. 26, opens both at once when desirable. This stay being screwed through the style of the upper ventilator, *c*, fig. 29, will open it alone, the lower portion remaining closed when the catch is not used, fig. 29. The ventilating-pins are screwed under the right-hand styles of the roof-sashes in such positions as to hold the stays securely by the holes when the ventilators are open or shut.

"The ventilators being all fixed, the cap, or ridge-board, *d*, fig. 28, is screwed on the top rail of the sashes, so as to fit close to the top of the ventilators when shut, and under the joint thus formed a small piece of board is slid into grooves made in the side styles of the sashes, so that any water draining through may be conducted to the grooves on the upper edge of the sash, provided for conveying drops to the gutter below, and under the bottom rail also a similar provision is made. The caps of lean-to houses are beviled to fit close to the wall and come down to the ventilators as in span-roofs.

"The ends are fixed under the styles of the roof-sashes, and are firmly secured by screwing on the plates, diagram 3, fig. 26.

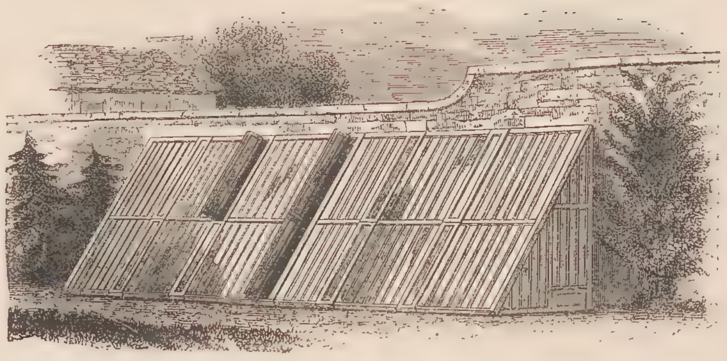
"The doors are hung in the usual manner, and may be had to open and lock either to the right hand or to the left, as may be desired." In figs. 30 and 31 we give, in addition to the illustrations at the beginning of this Essay, those showing a lean-to, and a span-roof hot-house on the principle now described.

Fig. 30.



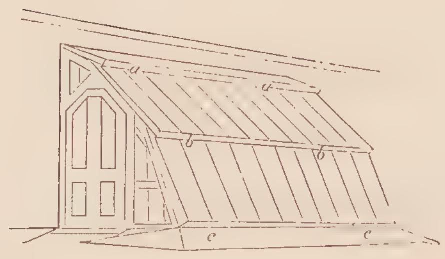
Span-roofed Hot-house on Paxton's Principle.

Fig. 31.



Lean-to Hot-House on Paxton's Principle.

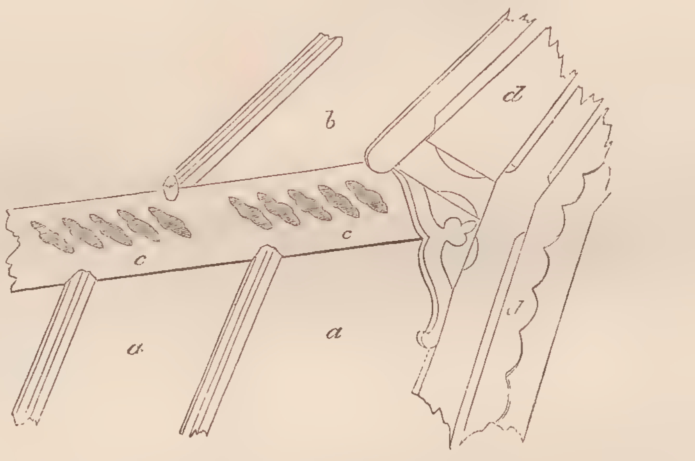
Fig. 32.



Lean-to House on Cranston's Principle.

47. We have now to notice the system of constructing and ventilating horticultural buildings, patented by J. Cranston, Esq., architect, 1 Temple Row West, Birmingham. The distinguishing feature of Mr. Cranston's system is the means by which a large supply of light and an extensively-diffused ventilation are secured. In fig. 32 we give a sketch showing the construction of a lean-to house; the ventilators are placed in the parts *a a*, *b b*. In fig. 33 we give an enlarged view of these; *a a* the lower sashes, *b b* the upper, *d d* the end of house; the diffused ventilation is secured by means of apertures *c c*, which run along the whole length of the building. The air, as it passes through these apertures, each of which is 2 or 3 inches long, and about half the width, all in parallel rows with the ground, is sub-divided into many small currents, never reaching the interior in large volumes, yet entering it readily, and filling it, as the ventilators may be open or shut, by few or many streamlets. The ventilating apertures are closed by means of sliding shutters in the interior of the house.

Fig. 33.



Details of Cranston's House, showing mode of Ventilating.

"The perforated radial ribs," says Mr. Cranston, "can be opened or closed, in a whole house, as quickly as you can stroll up and down it, a mere touch to small flaps, which are adjusted over the air openings being, according to one arrangement, all that is required to be done, and, as these flaps are generally about as long as the width of space occupied by two rafters, the ventilation can be as limited in extent, or as general in application, as may be judged best. There are neither cords nor racks, pullies, wheels, quadrants, rods, nor any such appliances; nothing, in fact, but flaps of the most inexpensive kind, so fitted and applied that air is excluded or admitted, everywhere or anywhere, with the greatest ease. There is nothing whatever in connection with this ventilation system that is likely to get out of order—no cords to break or cogs to snap off in the frost, no irons to rust and work stiff, or quadrants to get out of shape; but all is simple to a degree, and, as nearly as possible, self-acting, for the opening or closing a flap is, in the time occupied, or force employed, too small to be computed.

48. "Another plan of regulating the admission of air into these buildings has been most successfully carried out by placing valvular

slides, with friction rollers, in grooves over the perforated radial ribs, and connecting them in such a manner that one side, or one half side, of the house can be opened entirely or partially by moving a handle; and as the slide-valves are close-fitting and air-tight, they are, perhaps, more suitable than the flaps for houses where much artificial heat is employed. Care has been taken in each case to keep everything connected with the working of the ventilation system so simple, that the probability of its getting out of order is scarcely likely; but if any accident does happen, the construction is such that any workman can set it right without the least difficulty.

49. "After several trials which have been made with the glazing to some of these buildings, when used as conservatories or orchard-houses, the best plan appears to be to slide the panes into grooves on the sides of the rafters, and put them in without putty. The grooves should be a little wider than the glass is thick, the flatness of the glass allowing the panes to be pushed into their places from the lower ends of the rafters. A corresponding groove has to be made in the radial rib to receive the top end of each pane; and so far we have the two sides and the top ends of the glass panes resting in the grooves. As the glass does not fit tightly here, it must be secured from taking a downward motion and sliding out; this is done by screwing a small turn-button on the end of each rafter, the button being just long enough to go across the whole width of the wood, and catch the corners of the panes on each side of it, and hold them in their places. By giving these buttons half a turn, and making them vertical on the rafter end, instead of horizontal, the edges of the glass are free, and any pane can be drawn from its place as easily as it was placed there. And in the fine autumn weather, when it is important the wood of the plants should ripen and harden for coming winter, the whole or part of a house might have its glass removed by an ordinary labourer without risk or difficulty; and the same hand is equally competent at all times to effect repairs, or take out the glass if the house is to be removed, superseding the glazier, whose more expensive labour becomes quite unnecessary.

50. "Glazing of this kind has been watched and examined with the greatest attention during rain-fall of various degrees, and has also been tested by comparison with that in other houses, where the glass is fixed with putty, and laps are used; and it has been found that roofs glazed with long sheets of glass, in the manner described, keep out the rain at all times, when the other glazing always fails to do so; this defect being mainly owing to the capillary action in the 'laps.'

51. "The reasons which may render it important to build side-walls of bricks, and to use the valvular slides to the perforated ventilation plates instead of the flaps, may also apply with equal force to this mode of glazing, which might not be sufficiently air-tight for heated houses, in which cases the glass can be bedded in with putty in rebates, or in the grooves, as already described.

52. "It has already been said that these buildings are portable, and are constructed—without brick-work or stone-work—entirely of wood and glass. As we bring the glass down to the ground we do not want side-walls above the surface, and to get rid of them under the ground the buildings are placed upon butts of old trees, or blocks of any durable wood, let into the soil sufficiently deep to bear considerable weight without sinking. These blocks form the foundation upon which rests the wood-work, and should be about six or eight feet apart, and level all round. Solid planks come immediately upon the blocks, and are spiked down to them; and upon the planks the other parts of the house are secured.

53. "The only connection between the site—which might be the landlord's—and the building upon it—which might be the tenant's—is by the foundation-blocks, and as they are buried, it does not matter how rough they are; and being of little value, when the house is removed they need not be taken out of the ground.

54. "The parts of which these buildings are composed are the radial ribs, the rafters, the ground-planks, the ridges, and the ends, the whole being fitted and screwed together without mortising, tenoning, or framing of any sort, so that when it is necessary to pull down and re-erect the house, this can be done by any workman without waste of wood or glass, each rafter, as well as every radial rib or other part, being screwed together again as firmly as ever. Any gentleman fond of labour may, with the assistance of his servant, either pull down and refix one of these houses, or put it up in the first instance, for the pieces of which it is formed will fall into their right positions, to be fixed there by screws, as readily as an iron bedstead is fitted together. In new houses all the timbers will be numbered and marked, the screw-holes bored, and everything done, before they are packed up and sent off, to make the work of erection as easy as need be."

55. We now describe, in conclusion, the principle of erecting horticultural buildings, as patented by Mr. T. H. P. Dennis of Chelmsford, and this in the words of the patentee:—

"My invention consists in the arrangement of iron (as material), so that it may be erected or removed with great facility, provision being made for adding thereto without altering any part of the existing structure. To accomplish this I use wrought or cast-iron pillars for the main supports, attached to which are bosses having dove-tailed mortises, or joints, arranged to receive horizontal plates; the dove-tails to fit these mortises are formed from the solid wrought or cast-iron plates; either on one or both sides the end rafters are attached to the ridge by a sliding-bolt; the sash-bar, or intermediate rafters, are likewise fixed to the ridge and front plate, either by forming a hook from the end of the sash-bar, or rafter, or by affixing iron clips thereto, in the latter arrangement distance pieces are necessary.

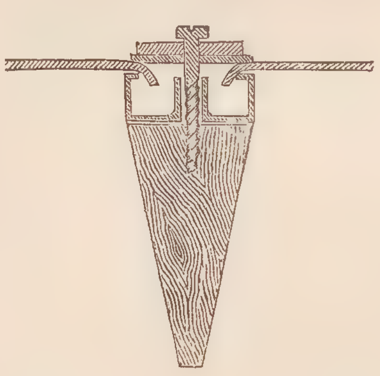
"The end bars, or 'lights' of a house, are fixed either with iron clips, having a mortise on the upper side to receive the bars, or by cutting mortises from the bars to fix up and clip the plates.

"The iron clips are made suitable for wooden structures where iron sash-bars are required. The pivots upon which the front sashes hang are formed from their own frames, and swing upon the iron mullion of the house; the sashes can be drawn entirely out. The dove-tail joints and fastenings, by which the sash-bars or rafters are held in place, are applicable to any shaped building. The dove-tail joint is applicable to framing for iron bed-steads and other purposes."

56. In Plate XVII. we give diagrams illustrative of some of the details of construction of Mr. Dennis' system. In figs. 12 and 14 the form of "iron clip" is shown, which is applicable to wooden structures with iron roofs, or for upright sash-bars of the same material. *h* is an iron clip secured to the walls or wall-plate by a screw; *k* is the sash-bar attached to it by a small pin; *i* is a V-shaped slot on either side of the iron clip, to admit a distance-piece being inserted after the clips are screwed to the walls. Fig. 13 is a plan of the same. Fig. 14 is another form of iron clip for wooden structures, which can be applied to "lights," door, and sashes. *h* is the clip, having the mortise through it corresponding with the iron sash-bar *k*, which fits into it.

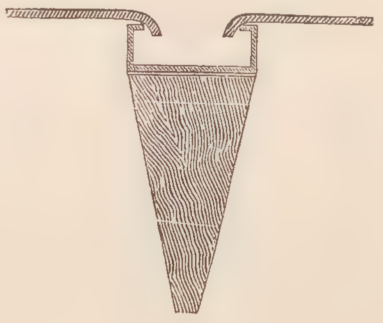
57. In figs. 34, 35, we illustrate the mode of having water-proof glazing without putty, introduced by Mr. T. S. Messenger of Loughborough. The glass is not left straight-edged all round, but has one edge turned down, which conveys the water into small gutters fixed in the sash-bars, or the upper part of the sash-bar is made with a gutter. Fig. 34 shows another method of fixing this glass, in which a screw passes through an india-rubber pad and brass plate, keeping the glass in place. The glass plates are so arranged that the condensed vapour inside the house is conveyed into the gutters as well as the rain externally.

Fig. 34.



Messenger's Mode of water-proof Glazing.

Fig. 35.



Another mode of water-proof Glazing.

ON THE ARRANGEMENT AND CONSTRUCTION OF SCHOOLS.

1. THAT the right arrangement and careful construction of the buildings in which so much of the time of our youth of both sexes is spent are points of primary importance few will be disposed to doubt or to deny. Yet it is unfortunately too easy a matter to prove that in many cases the sanitary claims of such structures have not been met—have, indeed, been altogether overlooked. It is possibly not an exaggeration of facts to state that in certain districts well-arranged schools, calculated to promote the health as well as the proper carrying on of the business of the pupils, are the exception—badly-arranged schools the rule. Of late, however, it has been very gratifying to note that vast improvements have been made in this department of architecture, and every day sees amongst us the introduction of some new mode of arrangement of the building, or of some form of apparatus calculated to make its business more surely and economically carried on. In furthering this improvement much has been done by the publication of the Reports of the Privy Council of Education, and by various isolated works. American and Continental writers have also done good service in this department, the question of public education receiving in their respective countries a vast deal more of practical notice than is unfortunately the case in our own. The writer of this article has had occasion to consult, for professional purposes, a wide diversity of papers and published suggestions on this important subject; and it has occurred to him that he might do practical service to the readers of this work by giving the most important of these a rapid *resumé*, illustrated by various sketches of arrangement, construction, and fittings, together with such remarks of his own as experience or observation on the American and European Continents have presented to him. The subject is indeed one of vital importance to the community, not only on account of the necessity, or rather duty, that exists for parents and guardians to see that the arrangements of schools are calculated to promote health, and habits of order and decency, but because—and it is important ever to remember this—education in the highest sense cannot be secured where the whole arrangements are not specially and perfectly carried out. Where the "location, construction, furniture, and arrangements," are not based upon a proper principle, they will hinder and not promote, defeat and not perfect the grand work of education. This principle, in the words of one of the most efficient authorities, is, "to make an edifice good for school purposes, it should be built for children and their teachers—for children differing in age, sex, size, and studies, and therefore requiring different accommodation—for children engaged sometimes in study and sometimes in recreation — for children, whose health and success in study require that they should be frequently and every day in the open air for exercise and recreation, and at all times supplied with pure air to breathe—for children who are to occupy it for periods of time in different parts of the day, in positions which become wearisome if the seats are not in all respects comfortable, and which may affect symmetry of form and length of life if the construction and relative heights of the seats and desks which they occupy are not properly attended to—for children whose manners and morals, whose habits of order, cleanliness, and punctuality, whose temper, love of study and of the school, are in no inconsiderable degree affected by the attractive or repulsive location or appearance, the inexpensive outdoor arrangements, and the internal construction of the place where they spend, or should spend, a large part of the most impressible portion of their lives. This place, too, it should be borne in mind, is to be occupied by a teacher, whose own health and daily happiness are affected by most of the various circumstances above alluded to, and whose best plans of order, classification, discipline, and recreation, may be utterly baffled or greatly promoted by the manner in which the school-house may be located, lighted, warmed, ventilated, and seated." Such may be taken as an exposition of the general principles affecting the arrangement and construction of schools; what the details of these are we shall in the course of our paper refer to.

2. Schools may be divided into two great classes—first, those having only one apartment; and second, those having two or more. It is needless to say that schools of the first class are in no wise fitted to carry out the purposes of education efficiently. It is impossible to educate a mass of children properly where means are not afforded of having the isolation of apartments perfect where different "classes" are carried on. The statement appeals to our common sense, and demands belief in its truth, that "a system of teaching and discipline, however good, can never be efficient if its practice is rendered difficult of attainment by arrangements which preclude the quietness and isolation so necessary."

3. In the Minutes of the Committee of Council on Education (1851-2) there are several plans of school arrangement given, some of which we now propose to illustrate. These, in the Minutes above referred to, were preceded with remarks on the essential points to be considered in the planning of schools, so much to the purpose, and so suggestive, that we deem it advisable to give them before presenting the plans.

"Before a school-room is planned—and the observation applies equally to alterations in the internal fittings of an existing school-room—the number of children who are likely to occupy it—the number of classes into which they ought to be grouped—whether the school should be "mixed," or the boys and the girls should be in different rooms, should be carefully considered, in order that the arrangements of the school may be designed accordingly. A. Every class, when in operation, requires a separate teacher, be it only a monitor acting for the hour. Without some such provision it is impossible to keep all the children in a school actively employed at the same time. The apprenticeship of pupil teachers, therefore, is merely an improved method of meeting what is, under any circumstance, a necessity of the case; and where such assistants are maintained at the public expense, it becomes of increased importance to furnish them with all the mechanical appliances that have been found by experience to be the best calculated to give effect to their services.

"B. The main end to be attained is the concentration of the attention of the teacher upon his own separate class, and of the class upon its teacher, to the exclusion of distracting sounds and objects, and without obstruction to the head master's power of superintending the whole of the classes and their teachers. This concentration would be effected the most completely if each teacher held his class in a separate room; but such an arrangement would be inconsistent with a proper superintendence, and would be open to other objections. The common schoolroom should, therefore, be fitted to realize, as nearly as may be, the combined advantages of isolation and of superintendence, without destroying its use for such purposes as may require a large apartment. The best shape (*see annexed diagrams*) is an oblong, about 18 feet in width. Groups of desks are arranged along one of the walls. Each group is divided from the adjacent group or groups by an alley, in which a light curtain can be drawn forward or back. Each class, when seated in a group of desks, is thus isolated on its sides from the rest of the school. The head master, seated at his desk placed against the opposite wall, or standing in front of any one of the classes, can easily superintend the school; while the separate teacher of each class stands in front of it, where the vacant floor allows him to place his easel for the suspension of diagrams and the use of the black board, or to draw out the children occasionally from their desks, and to instruct them standing for the sake of relief by a change in position. The seats at the desks, *and* the vacant floor in front of each group, are *both needed*, and should therefore be *allowed for* in calculating the space requisite for *each class*. C. By drawing back the curtain between two groups of desks the principal teacher can combine two classes into one for the purpose of a gallery lesson; or a gallery (doubling the depths of rows) may be substituted for one of the groups. For simultaneous instruction such a gallery is better than the combination of two groups by the withdrawal of the intermediate curtain, because the combined width of the two groups is greater than will allow the teacher to command at a glance all the children sitting in the same line. It is advisable, therefore, always to provide a gallery. The drawings annexed to the following rules purport simply to show the best internal dimensions of school-rooms and the best mode of fitting them up, the doors and windows being placed accordingly. The combination of such rooms with others of the same kind, with teachers' residences, and with the remainder of the school premises, as well as the elevations which may thereby be obtained, depending, as they always must, upon local circumstances, are not intended to be here shown. The committee of council do not recommend that the benches and desks should be immovably fixed to the floor in any schools. They ought to be so constructed as to admit of being readily removed when necessary, but not so as to be easily pushed out of place by accident, or to be shaken by the movements of the children when seated at them. The reasons of the following rule swill be readily inferred from these preliminary explanations:—

“1. In planning a school-room, if it be not more than 18 feet in width, about 8 or 9 feet square will be sufficient for each child in actual attendance. If the width be greater, there must be a proportionate increase of area allotted to each child.

“2. A school not receiving infants should generally be divided into at least four classes. (*The varying capacities of children between seven and thirteen years old will be found to require at least thus much subdivision.*)

“3. Parallel benches and desks, graduated according to the ages of the children, should be provided for all the scholars in actual attendance (*see Preliminary Remarks, B*); and therefore a school-room should contain at least four groups of parallel benches and desks (*see Rule* 2).

“4. A group should not contain more than three rows of benches and desks (*otherwise the distance of the last row is too great for the teacher to see the children's slates; and he must also raise his voice to a pitch which is exhausting to himself, and adds inconveniently to the general noise*).

5. As a general rule, no group of benches and desks should accommodate *more* than twenty-four children, *i. e.*, eight children in each of the three rows of the group, otherwise the width is too great (*see Preliminary Remarks, C*).

6. The proper lengths are 7 feet 6 inches for five children in a row; 9 feet for six in a row; 10 feet 6 inches for seven in a row; 12 feet for eight in a row; *i. e.*, 18 inches for each child.

[The other dimensions and details are shown in the annexed drawings.]

7. Each group of desks must be separated from the contiguous group, either by an alley for the passage of the children, or by a space sufficient for drawing and withdrawing the curtains. It will be sufficient to provide an alley for the passage of children *at one end only* of each group. At the other end a space of 3 inches will suffice for drawing and with drawing the curtains.

[Alleys intended for the passage of children must not be less than 18 inches wide in the smallest school, and need not be more than 2 feet wide in any school, unless where a door or fire-place requires a greater interval.]

8. The best width for a school-room, intended to accommodate any number of children between 48 and 144, is 17 or 18 feet. This gives sufficient space for each group of benches and desks to be ranged (with its depth of three rows) along one wall, for the teachers to stand at a proper distance from their classes, and for the classes to be drawn out, when necessary, in front of the desks around the master or pupil teachers. (*No additional accommodation being gained by a greater width in the room, the cost of such an increase in the dimensions is thrown away.*)

9. Where the number of children to be accommodated is too great for them to be arranged in five, or, at most, six groups, an additional school-room should be built, and placed under the charge of an additional school-master, who may, however, be subordinate to the head master, or a large school may be built on the plan of diagram No. 6. Where neither of these arrangements can be accomplished, the schoolroom should not be less than 32 feet wide, and the groups should be arranged along both sides of the room, the children in all cases facing the centre. (*But such an arrangement is very inferior to that of the single row along one wall. The opposite classes see each other, and their several teachers have to stand too close together. See Preliminary Remarks, B.*)

10. A curtain, capable of being readily drawn and withdrawn, should separate the several groups, but not so as, when drawn, to project into the room more than 4 inches in front of the foremost desk.

11. If the school-room be lighted from above—which is the best possible mode—great care should be taken to prevent the skylights from leaking, and to provide channels for the water which the condensation of the children's breath will deposit on the inside of the glass.

12. All sashes, both upper and lower, should be hung; and all windows, whether in the roof or elsewhere, should be made to open.

13. It is better to have a few large and well-placed windows than many small ones.

14. It is important to provide that the faces of the children and teachers, and also the blackboards and diagrams, should be placed in full clear light.

15. If the school-room be not lighted from above, there should be windows, if possible, at each end and one side of the room. The windows should be carried up as high as possible; and those which are placed at the backs of the children—an arrangement which should be avoided as far as possible—should not come down within 5 feet 6 inches, or at least 5 feet, from the floor.

16. When the benches and desks are arranged on both sides of the room it should be lighted from above, or there should be, if possible, windows in *each* of the side walls.

17. Except when a school-room is very broad there should be no fireplace in the centre of an end wall.

[A good place for a fire-place is under a window.]

18. The desks should be either quite flat or *very slightly* inclined. The objections to the inclined desks are, that pencils, pens, &c., are constantly slipping from it, and that it cannot be conveniently used as a table. The objection to the flat desk is, that it obliges the children to stoop. A raised ledge in front of a desk interferes with the arm in writing.

19. A large gallery for the simultaneous instruction of two or more classes, without desks, may advantageously be provided in a class room, or at one end of the school-room, for the reason stated in the *Preliminary Remarks, B.*

20. No such gallery, nor any gallery in an infant school-room, should be placed in front of a window, unless it be very high up above the heads of the children when they stand on the top row of the gallery.

21. No infant gallery should hold more than eighty or ninety infants.

22. An infant school should (besides a large gallery) have a small group of benches and desks, for the occasional use of the elder infants.

23. The alleys leading to a gallery should be at its sides, not in its centre. (*See Rules* 5 *and* 6.)

24. Great care should be taken that the valves which admit the fresh air into the school-room should be placed so as not to create a draught where the teachers and children sit.

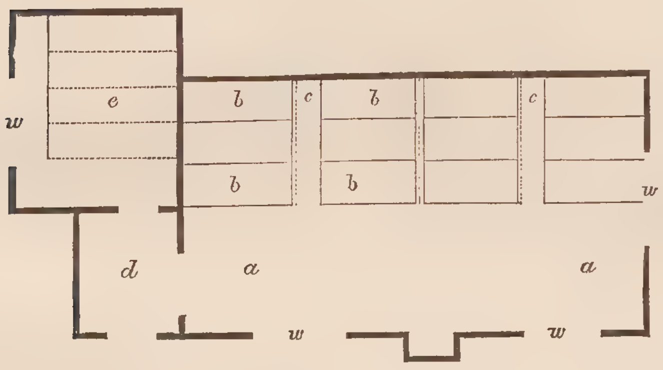
25. An easel and a blackboard should be provided for each class, and a larger blackboard for the gallery.

26. The dimensions shown in the drawings annexed to this memo-

randum are adapted to children of from 11 to 12 years of age. *It is very important that these dimensions should be graduated to suit the sizes of the elder and younger children in a school.*

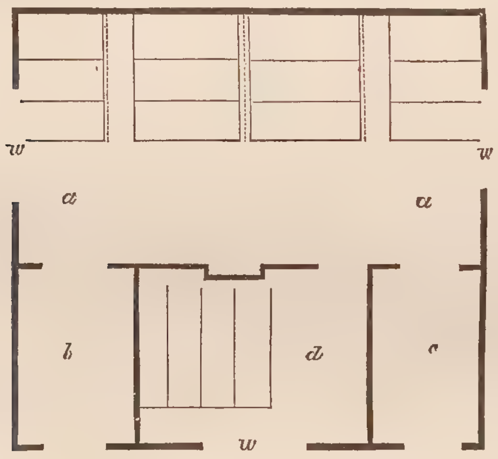
4. The following, figs. 1, 2, and 3, are the plans referred to in the above Minutes of Council. Fig. 1 is a school for 48 children of *one sex;* *a a* the class-room, 27 feet 3 inches by 16 feet; it contains four bays, as *b b*, each bay containing one class. The width of each bay is 6 feet, the width of passage *c* 18 inches; the dotted lines denote the places where curtains are hung. These curtains can be drawn up to make all the boys in one, or let down to separate them. From the porch *d*, which is 7 feet by 6 feet, a class-room, 12 feet by 8 feet, is entered. This is large enough to contain two of the classes which occupy the bays *b b b b*. Fig. 2 is a plan of a school for 48 children of two sexes. The class-room *a a*, 27 feet 3 inches by 16 feet, is entered by two porches *b c*, one for the girls and one for the boys; each porch is 9 feet by 6 feet. The class-room *a a* is divided into four bays, as in fig. 1, and a gallery *d*, 14 feet by 7 feet 6 inches, is provided, having accommodation for the pupils of two of the bays. Fig. 3 is the plan of a school for 72 children of one sex; *a* is the porch or lobby, 9 feet by 6 feet; *b b* the class-room, 39 feet 3 inches by 18 feet, 12 feet high, in which there are four bays, *c c c c*, 9 feet wide; *d* the gallery class-room, 18 feet by 12 feet. Fig. 4 is a plan of boys' and girls' school; *a* the porch, giving entrance to the boys' school-room *b*; *c* the porch, reached from *a* by the mid passage *l*, giving entrance to the girls' class-room *d*; *e* the girls' lavatory and cloak-room; *f* the range of water-closets; *g* the boys' lavatory and hat room; *h h* the water-closets; *i* the urinal; *j* the committee-room; *k* closet off ditto. An improvement in this plan would be the addition of class-rooms entering from porches *a* and *c* on the other side of the wall *m m*; or corresponding apartments to those on the boys' side, as at *g j*, might be made on the girls' side, making, in both cases, the room *j* serve as class-rooms.

Fig. 1.



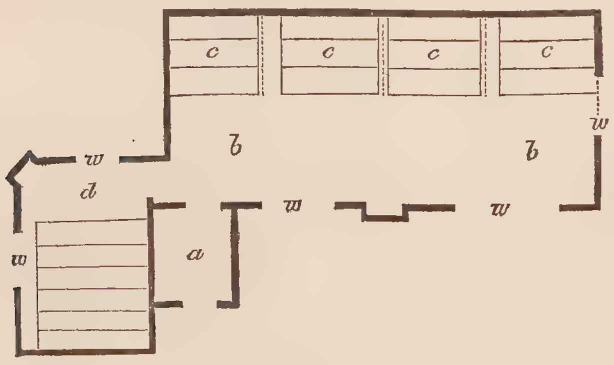
Plan of School for 48 children of one sex.

Fig. 2.



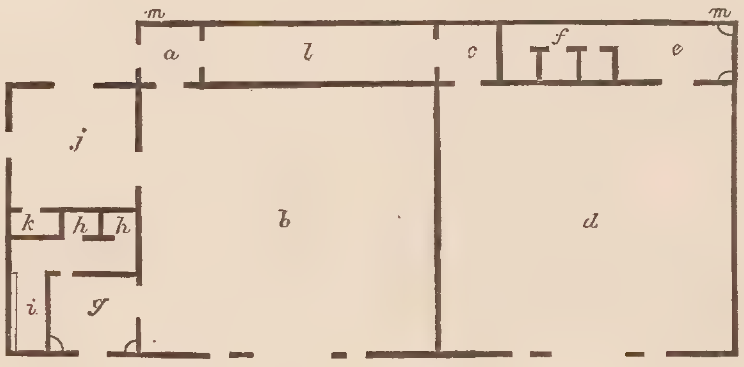
School for 48 children of two sexes.

Fig. 3.



School for 72 children of one sex.

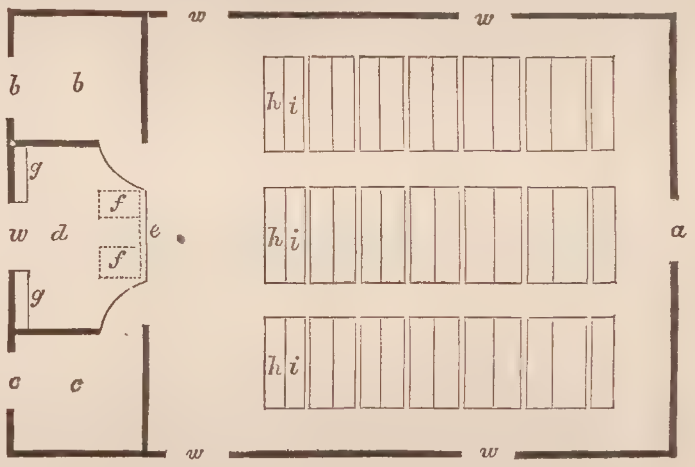
Fig. 4.



Plan of Boys' and Girls' School—Scale, 1-16th inch = 1 foot.

5. Fig. 5 shows an arrangement of an American school with one class-room; *a* the front entrance; *b b* girls' entrance and lobby; *c c* boys' ditto; *d* teacher's platform, with teacher's desk *e*, and library of reference, *f f*, in front of teacher's desk; *g g* closets for school library and apparatus; *h h* seats; *i i* desks; *w* windows.

Fig. 5.

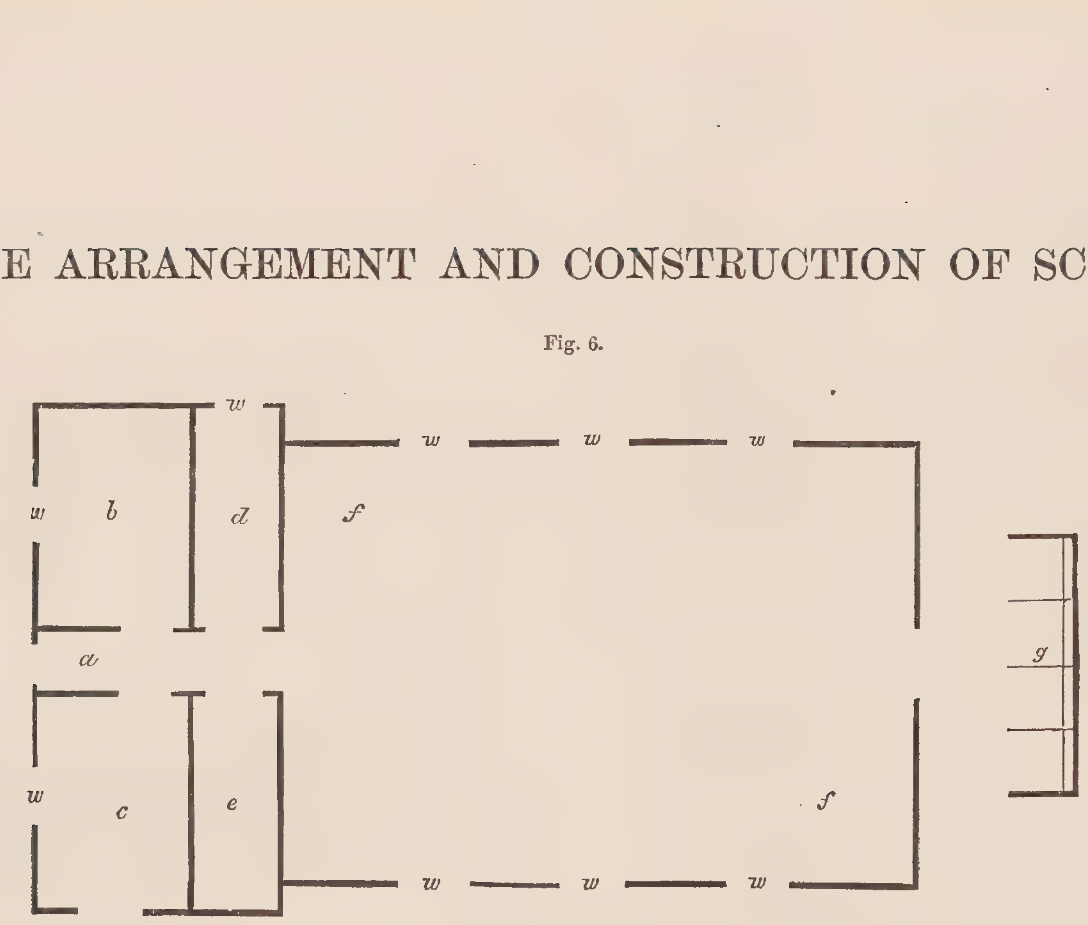


Plan of an American School.

6. Fig. 6 is the ground plan of a school on the Belgian principle of arrangement, to which the teacher's house is attached. *a* is the passage, or lobby; to the left is the boys' dressing and washing-room *b*, 2 metres 50 × 3 m. 50; to the right is the girls' room *c*, the same size. The library *d* is 3 m. 50 × 1 m. 90, and *e* is the position of stairs to second floor. The class-room *f f* is 7 m. × 10 m., and affords accommodation for 50 pupils; *g g* are the water-closets. In the chamber plan the master's house is placed, and consists of two bedrooms over the boys' and girls' rooms, *b* and *c*, fig. 6, a kitchen above the library *d*, and a small room above the passage *a*. Fig. 7 is the ground plan of a school on the Belgian principle, adapted for 80 pupils, with the master's house attached. The class-room is at *a a*, and is 8 metres wide by 12 metres long; it is entered by the two doors *b b*, or by the passage *d d*; *c* is the desk; *e* the girls' room, 4 m. 80 × 4 m.; *f* the boys' room, same size; *g* the stairs to upper floor. The accommodation of the master's house consists of a *salle à manger*, or dining-room, *h*, 5 m. × 4 m. 40; a kitchen *i*; and a small room *j*. In the upper floor there are two bed-rooms over the space occupied in fig. 7 by the passage *d*, rooms *h*, *i*, and *j*; and two other bed-rooms over the boys' and girls' rooms, *e f*,

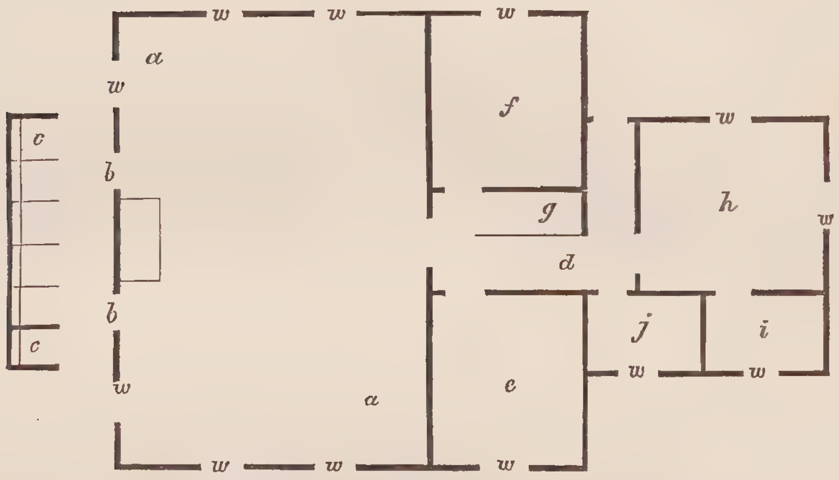
ON THE ARRANGEMENT AND CONSTRUCTION OF SCHOOLS.

Fig. 6.



Plan of a Belgian School for 50 Pupils, with Schoolmaster's House attached.

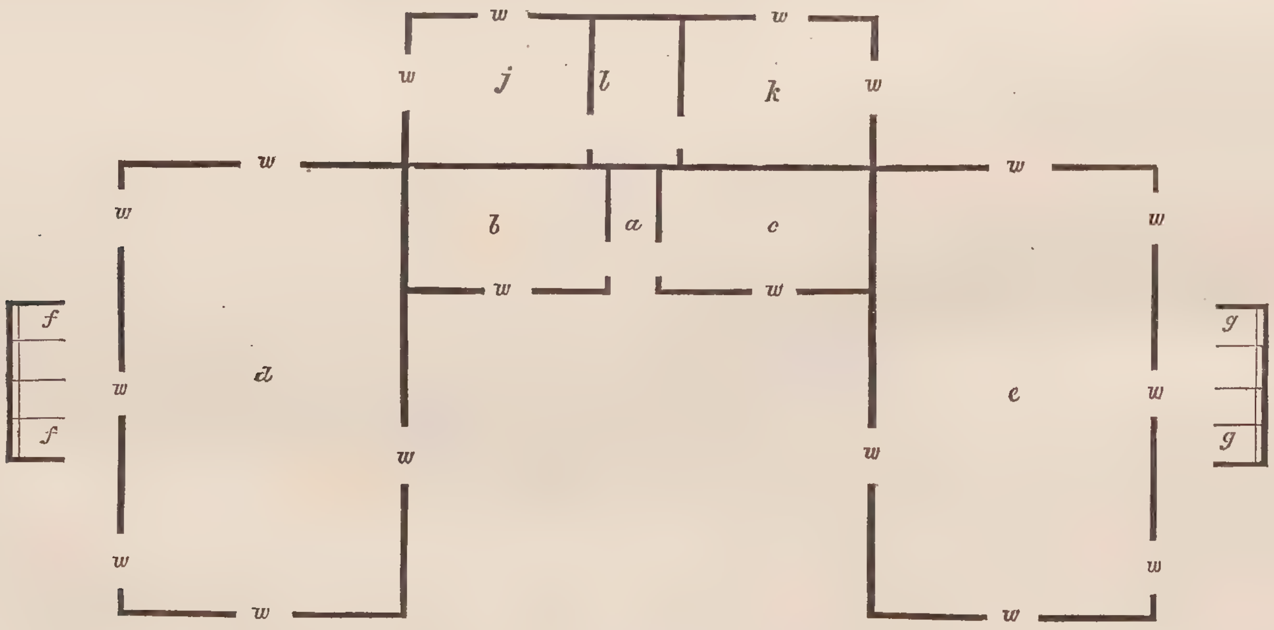
Fig 7.



Plan of Belgian School for 80 Pupils, with House attached.

in fig. 7. Fig. 8 is a plan of a Belgian school to accommodate 160 pupils. *a* is the central passage; *b* the boys' dressing and waiting-room, 3 m. 35 × 5 m. 50; *c* the girls' ditto. The boys' class-room, 7 m. 50 × 12 m., is at *d d*, with water closets *f f*. The girls' class-room—same size as the boys'—is at *e e*, with water-closets *g*. The passage for teacher's house is at *h*; *i* the position of staircase; *j* the dining-room, 5 m. × 30 m. 40; *k* the kitchen, 3 m. 40 × 2 m. 40. In the second floor, which is the part above *a b*, *c j k*, there are four bed-rooms.

Fig. 8.



Plan of Belgian School for 160 Pupils, with House attached.

7. In Plate XXIX. we give the elevation (fig. 1), transverse section (fig. 2), and ground plan (fig. 3), of a boys' and girls' school, and in the same plate the plan of a model infant school, issued under the auspices of the "Home and Colonial School Society," and which was designed by Mr. A. Blott of London.

8. In Plate XXX. we give in fig. 1 the ground plan, and in fig. 2 the one pair plan of a boys' and girls' school, of which the description will be found on the drawing. We are indebted for this plan to the work entitled "Model Designs for Villas, Cottages, &c."

9. In Plate XXX. we give in fig. 3 the ground plan of the Girls' Reformatory at Beernem, near Russeylade, Belgium. In fig. 4, we give chamber plan of this; in which A A are the washing-places and water-closets; B B cabinets, or closets; D linen-closet; E E chambers; F F bed-room for the domestics. In fig. 3, C C are cabinets; D D baths; E E, F, offices.

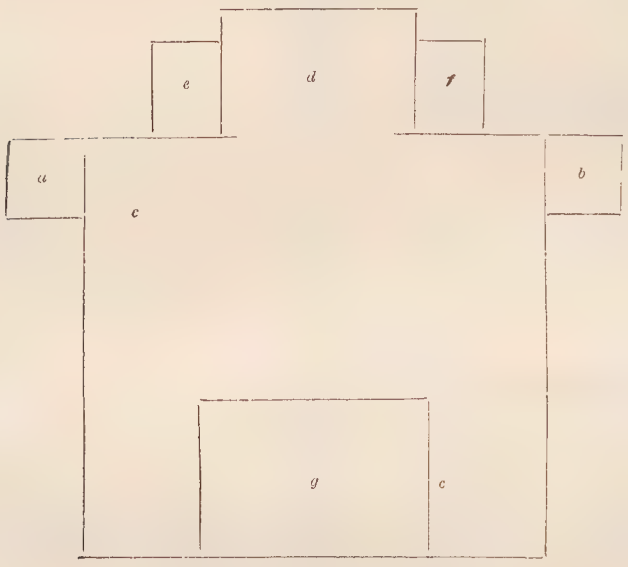
10. In Plate XXX., in figs. 5, 6, 7, 8, and 9, will be found illustrations of the Knellar Hall Training School, designed by George Mair, Esq., architect, London, and published under the auspices of the Privy Council on Education in one of their valuable blue books, from which we take them. In all the

plans *c* indicates the water-closets, *w* the washing-places. In fig. 6 *b* is the larder, *c* the wine-cellar. In fig. 8 *a a* are bed-rooms, *c* closet.

11. In Plate XXX., in figs. 10, 11, and 12, we give diagrams showing the arrangement of a primary school in New York, to accommodate 1,800 pupils. In the basement floor, fig. 10, *a a* are the water-closets; *b b* the girls' staircase; *c c* boys' ditto; *f f* the position of furnaces employed to warm the building; *d d* boys' play-ground; *e e* girls' ditto; *g g g* vestibules. In the first floor plan, fig. 12, *a a* the sliding doors dividing the class-rooms, but which can be thrown open to make the whole into one hall; *b b*, *c c*, *d d*, class-rooms; *e* teacher's desk; *f* wardrobe; *g g* book store, or library. In the second floor plan, fig. 11, *a a* class-room, 15 ft. 10 in. × 25 ft.; *b b* class-room, 15 ft. 10 in. × 18 ft. 6 in.; *c c* corridor, 5 ft. wide; *e e* class-room, 15 ft. × 17 ft. 6 in. In all the class-rooms *d d* indicate the position of the wardrobes.

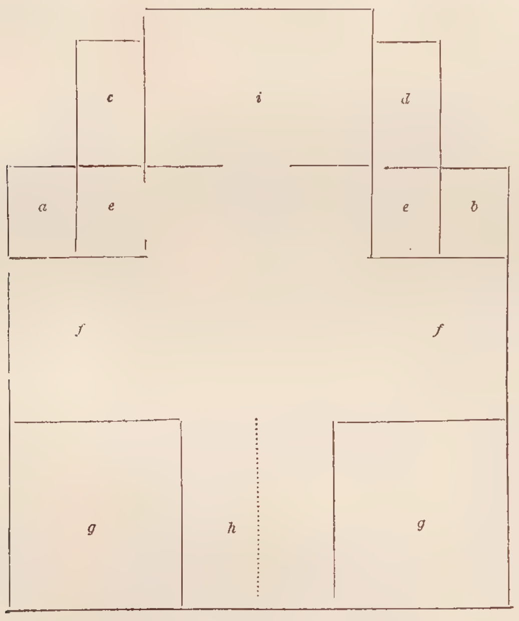
12. It would be an easy thing to multiply examples of school arrangement; we therefore proceed to detail various points connected with their construction; before doing so, however, we deem it likely to be useful if we give a few more outline type sketches of other arrangements. Fig. 9 is the plan of a small, or village school. *a* girls' porch; *b* boys' ditto; *c c* the school-room, 35 ft. by 25 ft.; *d* the class-room; *e* girls' water-closet; *f* boys' ditto; *g* the gallery in school-room. Fig. 10 is another plan of a school adapted for a village district. *a* girls' porch; *b* boys' ditto; *c* girls' water-closet; *d* boys' ditto; *e e* closets for hats, cloaks, &c.; *f f* the school-room; *g g* the galleries, divided by a curtain in the position shown by the dotted lines *h*; *i* the class-room. Fig. 11 is the plan of a school, showing the arrangements adapted for a suburban, or town district, in which *a* is the girls' porch; *b* the girls' cloak-room; *c* the girls' water-closet; *d* the girls' class-room; *e* the boys' porch; *f* the boys' hat-room; *g* the boys' water-closet; *h* the boys' class-room; *i i* the school-room, with galleries *j* and *k*. Fig. 12 gives the plan of a town training school, consisting of three schools, with class-rooms and master's house attached; *a*, *b*, and *c*, are the three entrance porches; *d d d* hat and cloak rooms; *e e e* book closets; *f f f* school-rooms; *g g g* galleries; *h h h* class-rooms. Each school-room has a separate play-ground, provided with water-closets, and the master's residence may be at one side, and connected with the school by a covered way. In determining the sizes of apartments 6 square feet should be allowed for each scholar. Thus, a school-room 50 ft. by 27 ft. should accommodate 225 children.

Fig. 9.



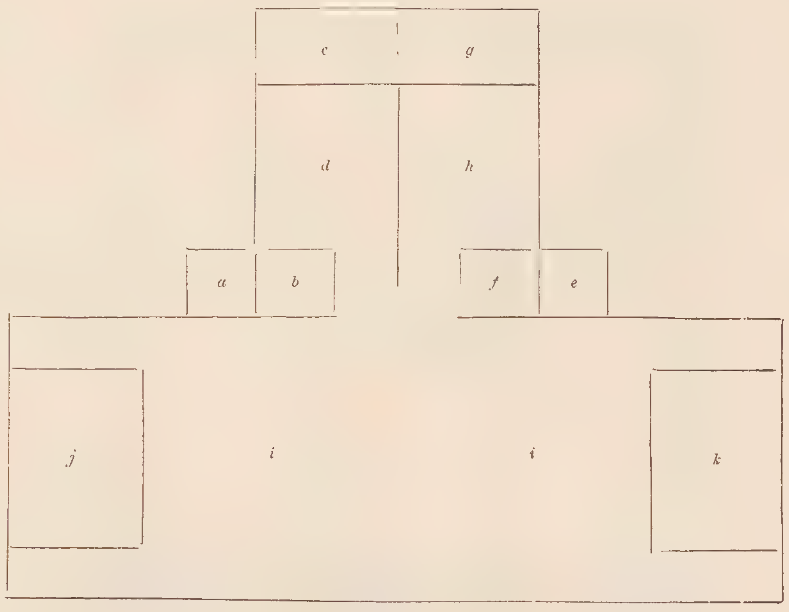
Ground Plan of Village School.

Fig. 10.



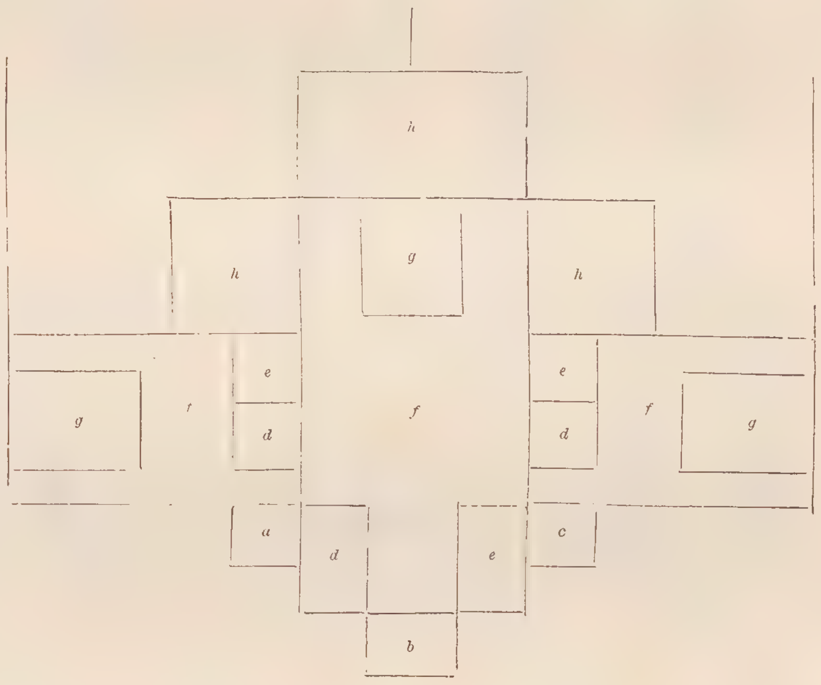
Ground Plan of Village School.

Fig. 11.



Ground Plan of a Suburban, or Town School.

Fig. 12.

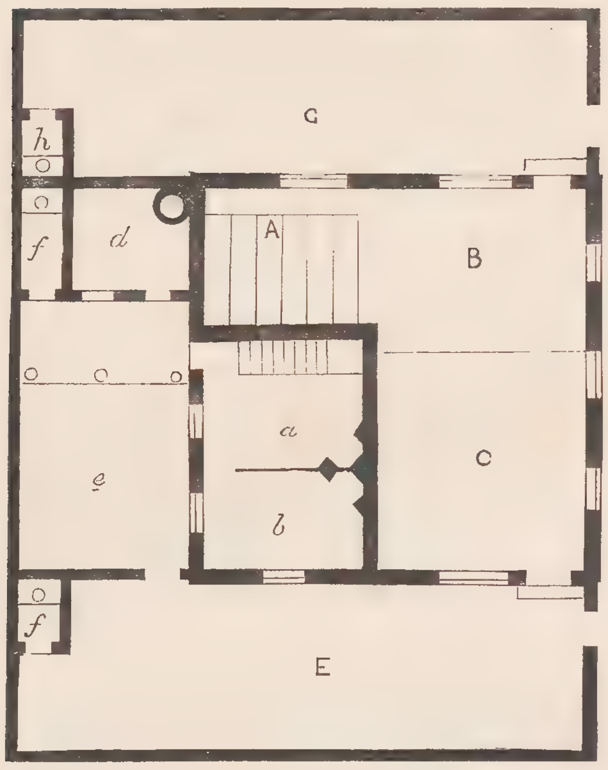


Ground Plan of Town Training School.

13. In the Rev. Mr. Moseley's Report of the Schools of the Midland District in the Minutes of the Committee of Council on Education, plans are given of schools having different accommodation. In fig. 13 we give a plan of a school adapted for 100 boys and girls, with a master's house attached, in which *a* is the kitchen; *b* the sitting-room of the house; *c* the position of stair to second or bed-room floor; *d* the scullery in the yard *e*; *f* water-closet. In the school A is the gallery for oral instruction; B the writing-school, 17 feet wide; C the morning reading-school, 17 by 18 feet, used in the afternoon for a sewing-school for the girls. A curtain, indicated by the line, divides it from B; E the yard for girls, with water-

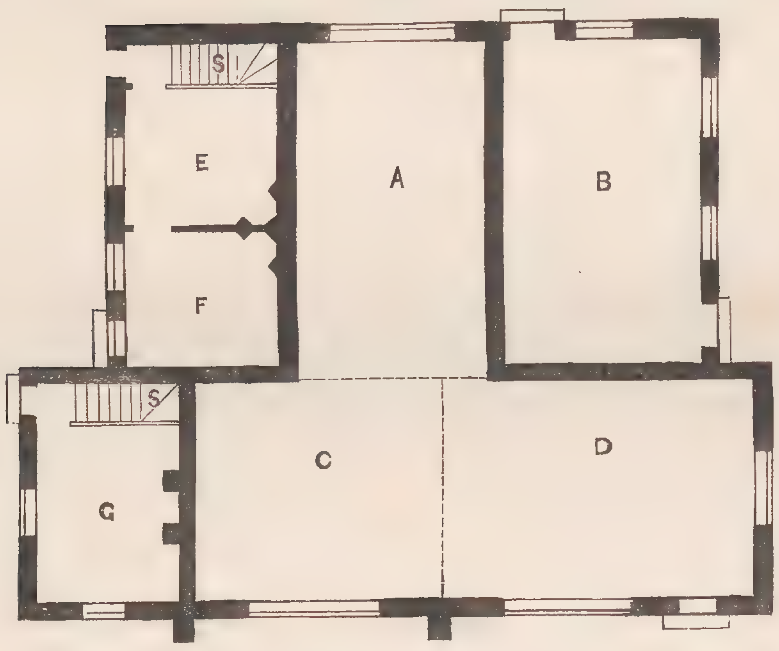
ON THE ARRANGEMENT AND CONSTRUCTION OF SCHOOLS.

Fig. 13.



Plan of Schools for 100 Boys and Girls, with Master's House attached.

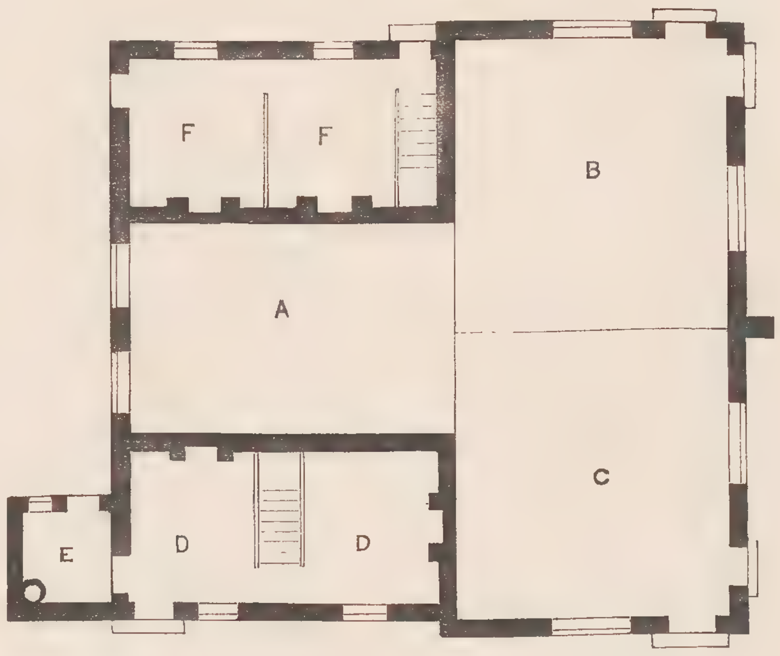
Fig. 14.



Plan of School for 220 Boys and Girls and 100 Infants, and with Houses for Master and two Mistresses.

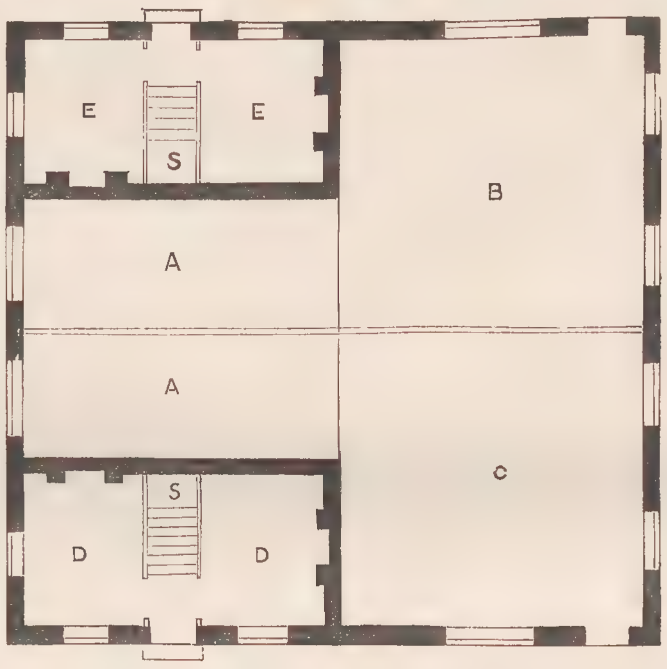
closet *f*; G the yard for boys, with water-closet *h*. Fig. 14 is the plan of a school for 220 boys and girls and 100 infants, with a house for a master and two mistresses. A is the room for oral instruction for 72 children, 27 feet by 16 feet; it is divided by a curtain from the writing-school C, for 64 children, and which is 20 feet by 19 feet; this is divided by a second curtain from the room D, which is used as a morning reading and afternoon girls' sewing room—its dimensions are 26 feet by 19 feet, and is calculated to contain 82 or 100 children; B is the infants' school for 100 children, 27 feet by 17 feet. In the house or residence department, E F is the master's house, if married; G the mistress of the infant school; *s s* indicate the position of stairs to bed-room floors in both houses. In fig. 15 the school is for 250 boys, and there is a residence for a head master and two assistant masters. A is the school-room for oral instruction, 23 feet by 20 feet, divided by a curtain from the writing-school B, 24 feet by 23 feet; this is divided by a second curtain from the reading-school C, 24 feet by 23 feet; D D the master's house; E the scullery; F F the assistant masters' house; the stairs to bed-room floors are shown. In fig. 16 A A are the rooms for oral instruction; B the writing-school, 25 feet square; C reading-room, ditto; D D master's house; E E assistant masters' house; *s s* stairs to bed-room floor. If there should be no master's residence given to this plan, the school will accommodate 400 children in place of 300. Elevations of figs. 13, 14, 15, in Plate XX.

Fig. 15.



Plan of School for 250 Boys and Girls, with Master's residence.

Fig. 16.



Plan of School for 300 Children, with Master's residence—for 400 without.

14. Having thus given various plans of school houses, showing their arrangement, we propose to glance briefly at the points connected with their construction, these being, first, *site;* second, *drainage;* third, *water-closets and yards;* fourth, *warming and ventilation;* fifth, *lighting of the rooms;* and sixth, *interior fittings.*

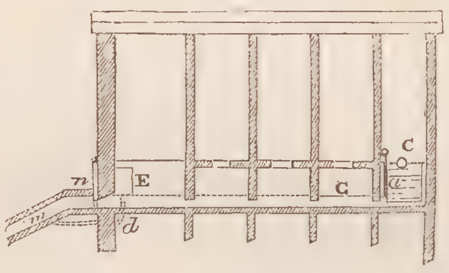
15. *Site.*—In the building of school-houses in towns a narrow range of choice is usually within the command of the architect; but as far as possible the site selected should possess the advantage of being roomy and airy, so that ample space for playgrounds—and these well open to the winds—may be obtained. If space is so confined that playgrounds cannot be obtained outside of the building, this should be raised up on strong supporting arches, so as to leave an open-sided basement, which should serve as a playground. In suburban and rural districts the site should be chosen in such a locality, that not only ample space may be secured, but that the surrounding scenery may be beautiful and cheery. The aspect of the school should be sunny, and the grounds around and near it laid out with taste and skill, displaying at once the beauty of order and the delights and fragrance of flowers. For it should never be forgotten by the school architect, that if it is true as the poet so well expresses it, "A thing of beauty is a joy for ever," that youth is the time when a love of the beautiful and of order can best be inculcated and fostered, and

that this can be best aided by the well-ordered and well-filled garden. This is indeed, what it has been well called, "the uncovered school-room of physical and moral education, and the place where the manners and the personal habits of children can be better trained than elsewhere." Where space can be obtained, we plead earnestly for a beautiful garden being attached to, and within sight of, the school. A variety of privileges in connection with the admission to, and cultivation of, tiny plots in it might be inaugurated by a judicious master in connection with this addition to a school. If such a site is obtainable, a gently-sloping declivity to the south-west should be chosen, as it is the best, and it will be all the better if protected from the biting north-east winds by a clump of trees. It should not be too near the road—remote enough to escape from its clouds of dust, and be away from its noise and bustle—yet near enough to be easily accessible by a well-kept path. A damp marshy spot should be avoided. If tall trees can be obtained in the neighbourhood they will add much to the pleasantness of the site, although they should not be too numerous, or too near the school to throw it into shade.

16. The *drainage* of the site for the prevention of damp, and the drainage to carry away the products of the water-closets and the master's residence, are of essential importance, and must not be overlooked. Nearly all that can be said on the subject has been already said in Essay Sixth in this work, taking up the subject of drainage, to which we refer the reader. We therefore proceed to the next point.

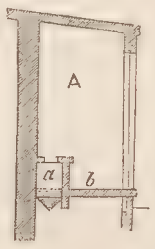
17. *Water-closets, Urinals, Lavatories.*—It is impossible to overestimate the importance of the subject of water-closets. As we have elsewhere remarked, "in view of the pernicious physical and moral habits resulting from the *want* of such conveniences (in schools), it is indeed difficult to realize the truth of the fact—alas! too patent—that little or no attention (in some districts) is paid to this important point." Indeed, the depraved habits which will contaminate a lifetime may be begun early to be instilled into the pupils, "if proper care, as regards the arrangement and the *general supervision of the attendance* on these places, be not carefully taken and looked after by the master." Over this portion of the school premises the most perfect neatness, seclusion, order, and propriety, should be enforced, and everything calculated to defile the mind or modesty of the most sensitive should be immediately removed; and any vulgarity in respect to it on the part of the pupils should receive attention in private, and be made a matter of parental advice and co-operation. Neglect in this particular on the part of the community in providing suitable buildings and premises, or of the teacher in enforcing proper regulations, has been followed with the most disastrous results to the health and happiness of thousands of pupils." The accommodation in this respect should be ample, and the seats so arranged that they be in rows — not opposite to each other, *which is highly objectionable*—and each seat should be perfectly isolated from its neighbour by a high partition, and coming well forward also before the seat, at least 2 feet. The floor should be of slate or well-polished flag, and be laid with an incline from the front of the seats to the wall opposite; and running along the front of the seats, and on the level of the floor, should be a perforated pipe. When water is turned on through this pipe it will flow over the surface of the floor to the wall, at which place openings should be made leading to an under drain, communicating with the main sewer or liquid-manure tank. The floor can thus be easily flushed and kept clean. It is of essential importance that each house should be exceedingly well lighted. Indeed, in all places where dirt is apt to be collected, an excess of light—or that which would in other places be deemed to be such—will be better than any approach to deficiency. For let it be remembered that dirt flies from light. It is scarcely necessary to say that an ample supply of water should be provided for the purpose of cleansing out the pans of the closets, although it is questionable how far the use of the generally-employed forms of apparatus is to be recommended for schools, for the pupils, at their careless time of life, can scarcely be expected to use them, at least regularly and carefully. Possibly an arrangement, such as has been proposed by Mr. Richson in his School Builders' Guide, may be the best to adopt. We illustrate this in fig. 17, which is a longitudinal, and in fig. 18, which is a cross section: "*a*, fig. 18, the seat, with the water-channel to the level of the floor; at the back and front of *a*, dipping 1 inch into the water, is a Valentia slate E, 1 inch thick, to act as a urinal. The channel, though here drawn angular, would be better of an oval form; *b* shows the level of the floor. In the longitudinal section, C is the cistern, with ball-tap and sliding valve *a* to flush the channel G; *n* a sliding-valve to let off the water, and pass it off to the drain *m*; *d* is an overflow pipe." The following are the recommendations of the Privy Council on Education in connection with privies or water-closets:—"The privies for boys and girls should be completely separated, at least by a dust bin, or other sufficient obstacle to sound as well as sight. They must be provided with a sufficient supply of water to cleanse them thoroughly. Their drainage should be effected by earthen pipes, glazed inside, of 3 or 4 inches diameter, properly cemented at the joints, and trapped. The syphon soil-pans for cheap water-closets may now be obtained from 25s. to 30s. a-piece. The seats should be separated one from the other by partitions of slate or wood. The doors and passages from the school-room to the privies for the two sexes should also be distinct." Mr. Wilderspin recommends that the water-closets should be placed near the small class-room, and should be within the range of inspection of the teacher, this being secured by small traps covered with spring lids. Any one of these traps should command the range of the closet. Mr. Wilderspin truly remarks, that there is nothing in which children, especially of the humbler ranks, require more training than in their behaviour and treatment in and of the water-closet. *Urinals* for the boys should also be provided, and these separate and distinct from the water-closets, and every care should be taken to keep them clean. The urinals manufactured by Jennings of London are by far the best we are acquainted with. In place of having them ranged along the walls of a separate building, we should be inclined to recommend the plan of having a circular or octagonal arrangement in the centre of the apartment or enclosure. The school will be all the more complete and perfect in those arrangements which are so well calculated to cultivate proper feelings of personal respect and cleanliness if *lavatories* are supplied to the cloak rooms, both of the boys and of the girls.

Fig. 17.



Longitudinal Section of Water-closet.

Fig. 18.

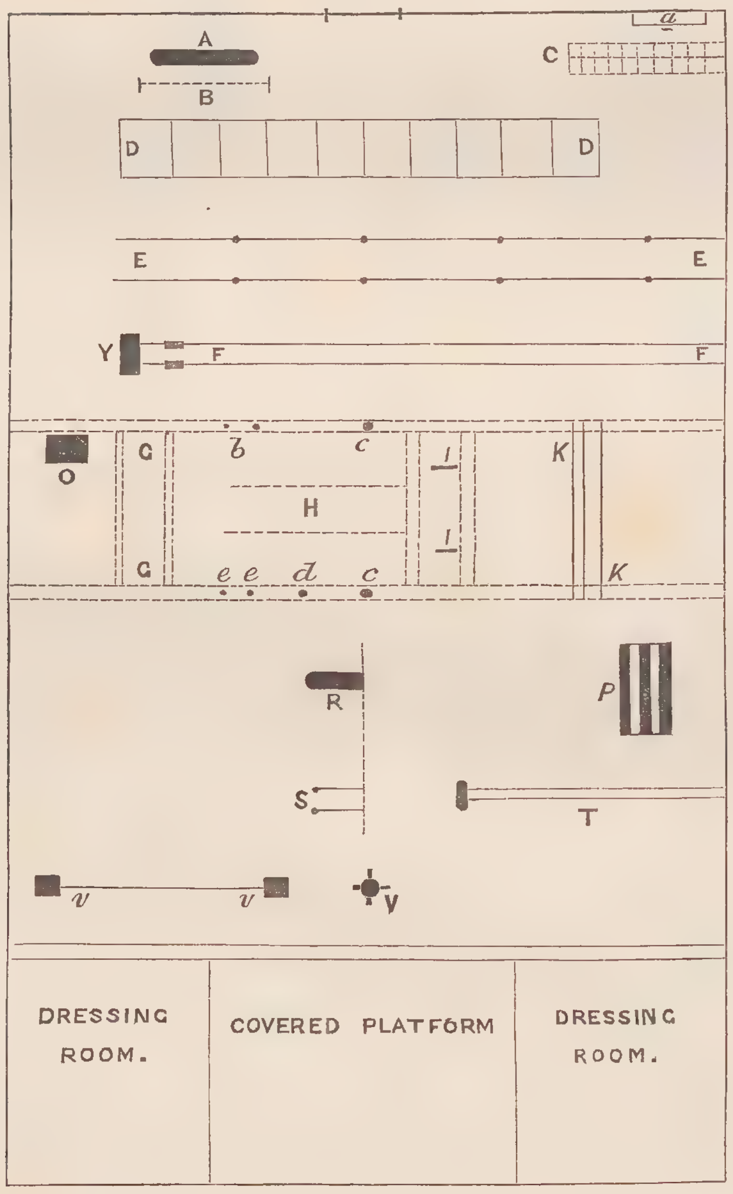


Transverse Section of Fig. 17.

18. *Yards or Play-grounds.*—It is of essential importance that each department of the school appropriated to the sexes should have a play-ground or yard attached. This should be of the largest possible dimensions, walled or railed in with a close paling, to a height of at least 6 feet. The ground should be levelled, and made up of compact, well-rammed gravel, and the greatest care taken to prevent the formation of rain-holes.

We know of no material so well adapted for the formation of yards as the asphalted pavement now so largely introduced; mixed as this is with pounded granite or with shells, it forms a surface as pleasant to look as it is so to walk upon. It has been recommended by authorities who take a high view of the importance of education, to give a degree of elegance to the surroundings and arrangement of the play-grounds, as by this means a lesson can be afforded which may contribute to refinement of manners as well as comfort in life. "It may lead not only to clean and comfortable dwellings, but to a taste for decoration and beauty, which will tend mainly to expel coarseness, discomfort, dirt, and vice, from the economy of the humbler classes." It will be difficult to controvert this view, however much it may be so to some of our readers to agree with the mode of carrying the lesson out as recommended by these authorities so far as the decoration of the play-yard is concerned, namely, by decorating its walls with fruit and flower trees, and running round it a fenced-off border, tatsefully laid out with choice flowers and shrubs. This may be thought a refinement in school arrangement; as to its good effect, however, on the pupils no one will doubt. As gymnastic exercises are so much recommended for youth, it will be advisable to fit out the play-ground with a full set of *gymnastic apparatus*. In Mr. Barnard's work on *School Architecture*, a full description of the varieties and arrangement of apparatus of this kind is given, an epitome of which we now present to our readers as being likely to be highly useful. The plan of the yard, as fitted up with the apparatus, is shown in fig. 19, and is the arrangement adopted in the "Collegiate and Commercial Institute" of Newhaven, U.S.

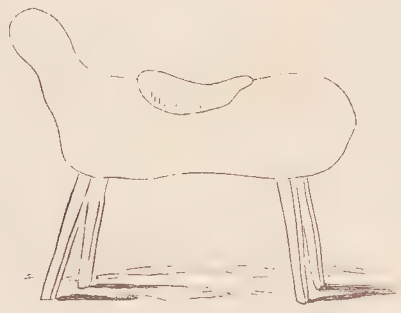
Fig. 19.



Plan of Play-yard fitted with Gymnastic apparatus.

The following is the description and special illustration of the apparatus which Mr. Barnard gives:—"The wooden horse A (see plan in fig. 19, and special illustration in fig. 20) is a log, which may be preferred rudely fashioned, like a horse's body, and is set upon four legs, about breast high.

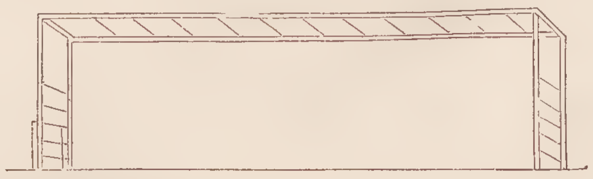
Fig. 20.



Wooden Horse.

Two cross pieces, which do not appear in the cut, should be set transversely in the places of the pommel and cantle of the saddle, raised high enough to allow of being well grasped by the hand, and rounded over the top. The exercises upon this machine are leaps and vaulting with the help of the hands, which are set upon the above cross pieces, or on various parts of the machine. B is a *spring-board*, an elastic plank raised upon blocks at the ends to assist the spring. It is, however, doubtful whether such aids are desirable, for they do not habituate the pupil to the unyielding surface from which leaps must generally be taken. The wooden horse exercises give elasticity and spring to the frames, and are useful to riders. C, in plan, fig. 19, is a *slanting ladder*, and D, illustrated in fig. 21, a *horizontal* one. The exercises upon these consist in hanging upon or under them, and passing from one end to the other, by means of the hands alone, in various ways, and are intended to strengthen the gripe, the arms, and the shoulders.

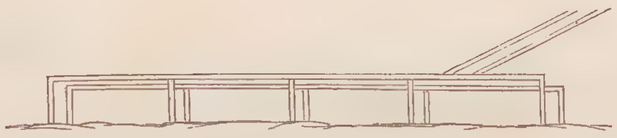
Fig. 21.



Horizontal Ladder.

The slanting-ladder may run at an angle of about 45°, from a base about 4 feet high to an altitude as great as is convenient. E, fig. 19 in plan and in fig. 22 in perspective, is a pair of *parallel bars*, both horizontal and slanting.

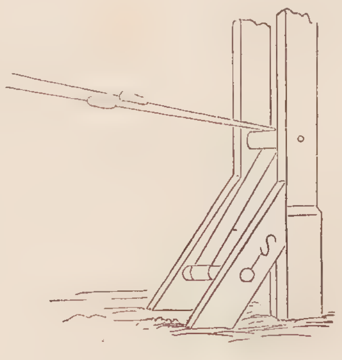
Fig 22.



Parallel Bars.

The exercises upon this machine widen the shoulders, open the chest, and strengthen that and the shoulders. They are somewhat difficult, but exceedingly strengthening. The bars are large enough to grasp, say 2½ inches in thickness by 3½ deep, set upon strong uprights, so framed that the uprights at their insertion do not extend beyond the bars. About 5 feet is a proper height for the upper side of the bars. F, fig. 19, is a pair of *inclined ropes*, with their sliding boxes. The windlass at Y, with a stout ratchet, is used to keep the ropes strained tight. This machine, fig. 23, is not very useful;

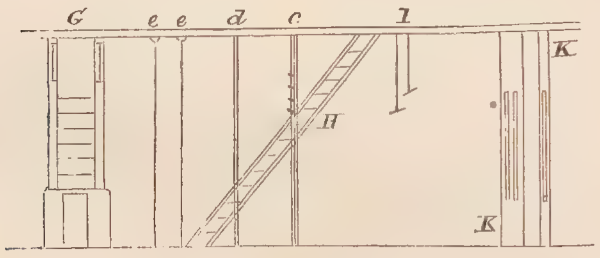
Fig. 23.



Inclined Ropes.

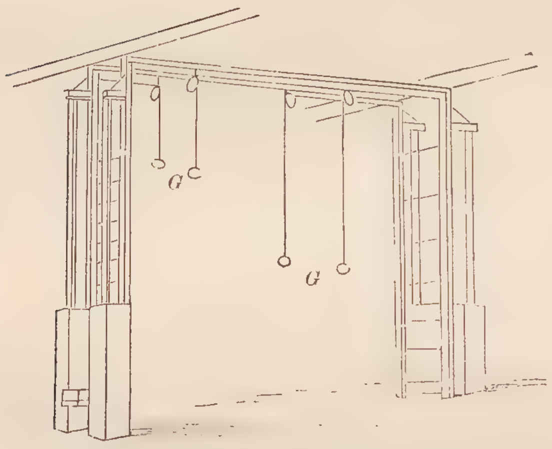
the principal operation to be performed upon it being to put the sliding boxes under the arms, and progress up the ropes by swinging the body. The machines marked G, H, I, K, O, *c*, *d*, and *e*, are fixed between timbers and cross pieces, whose places are shown by dotted lines in the plan, fig. 19. The weights G G, fig. 25, run in wooden tubes, and are suspended upon ropes, at the other end of which are rings for handles, seen hanging down in the cut. These are used to exercise the arms, and the exercises upon them are capable of rapidly developing the muscles of the fore arm, upper arm, shoulder, and chest. They are performed by drawing or pushing out the weights with the fingers, hands, or feet, in various positions. H, fig. 24, is a *slanting ladder*, such as was above described. I, fig. 24, is a double running rope, running over two sheaves set in a cross piece upon the timbers overhead, and with a stout wooden handle, hung by the middle, at each end, so that these handles hang loose, perhaps 6 feet apart, and 5 or 6 feet from the ground. Two persons of nearly equal weight are best fitted to use this machine. One jumps up a few inches, while the other weighs down upon his end of the rope so as to keep it strained tight; and as the first comes down again, the second jumps in his turn, the motion being increased if desired until the jumps carry the hands up to the timber overhead, and the lower of the two pupils crouches down to the ground. K, figs. 19 and 24, and in perspective in fig. 26, is a single and double *vaulting-bar*. The bars are moveable in slips in the uprights, and are set at any desired height by iron pegs running in holes in the uprights and through the bars. The bars, either alone or together, are used for performing jumps from the ground, with the hands on the bar, and for various other exercises with the feet off the ground. The vaulting exercises strengthen the body above the waist and the arms. O, fig. 19, is a *trapezium*, or bar-swing,—a hard wood cross-bar, hung by two ropes, and which should be about 5½ or 6 feet from the ground. The trapezium exercises are numerous, and consist of jumping, swinging, and turning in many ways. They are not very difficult, and quite pleasant to perform. *e e*, figs. 19 and 24, are two upright ropes for climbing, and *d* is a perpendicular pole for the same purpose. These should be as high as the building arrangements will allow. *c c*, figs 19 and 24, are upright poles, with pegs in them, fitting loosely into holes. These poles are to be climbed by taking a peg in each hand, and setting them one after another into the holes. At *b*, in fig. 19, are two upright poles at about the width of the shoulders apart. These may be used for climbing, and for exercising the chest, by holding the poles, one in each hand, nearly shoulder high, and pushing the head and shoulders through between them. P, fig. 19, is a wide spring-board for jumping forward. R is a *rope swing*. S, fig. 19, is a pair of *iron rings*, hung upon single ropes from a bar overhead, about as high as the trapezium, and the exercises upon them are of the same character, though more varied, difficult, and pleasant. They demand and develope great quickness, and strength of arm and chest, and if practised with care, are among the most useful of the gymnastic exercises. T, fig. 19, is a *spring-beam*, set firmly in the wall, and resting upon a fulcrum a short distance from it, so as to furnish considerable elastic force. It is used for perpendicular jumping. V, figs. 19 and 27, is a *flying machine* or *rotary swing*; *v v*, fig. 19, is a *moveable leaping stand*, for standing or running jumps. It consists of two light uprights, set in heavy bases, so as to stand firmly, and with a row of holes, 1 inch or 2 inches apart, at corresponding heights in each. Pegs fit into these, over which, at any desired height, may be hung a string with a weight of about five pounds at each end. By this means all danger of catching the feet in jumping is avoided, as a light touch throws the string off the pegs. Fig. 28 is a *horizontal beam*, a stout square stick of hard wood, about 20 feet long, with tenons at each end, running in slits in the uprights. Iron pins pass through the uprights, and through holes in the tenons, and hold the beam at any height desired. The uprights may stand about 4 feet above the surface of the ground, and the holes in them may be 3 inches apart. The beam should not be less than 4 inches square. This machine is used for various leg exercises, which are of considerable value."

Fig. 24.



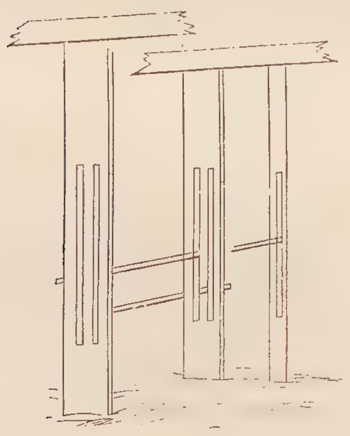
Gymnastic Apparatus.

Fig. 25.



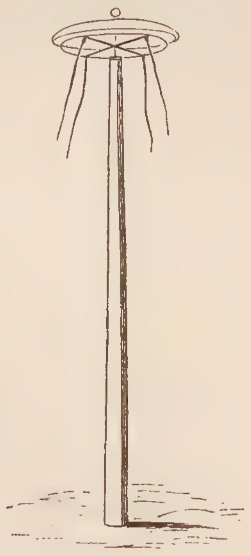
Perspective View of part G in figs. 19 and 24.

Fig. 26.



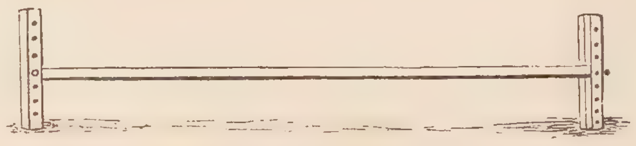
Vaulting Bars.

Fig. 27.



Swing.

Fig. 28.



Horizontal Beam.

19. *Warming and Ventilating.*—In Essay Fifth we have gone so fully into the principles of ventilation and of warming, with examples showing their application in practice, that we have here but little more to do than explain those special arrangements which have been introduced in American schools with such decided success, and which we have illustrated in Plate XXXIII. Fig. 25, Plate XXXIII., is a diagram of the arrangement for warming and ventilating the Eliot schoolhouse in Boston. In this two stoves are placed in the base-

ment, and supplied with cold air through the channels *a a*; the heated air is delivered to the two rooms above by the channels as shown. The foul air is led off from the rooms by channels leading to the space between the roof and the ceiling, and from which it is passed to the atmosphere by the ventilator *c*. To aid the draft a gas-burner is placed at the foot of the shaft. It is to be noted that the plan here illustrated was an improvement on the old plan, the channels of supply and exit being in the original building all too small. Fig. 26, Plate XXXIII., illustrates the arrangement for warming and ventilating the Endicott school-house in Boston. Two furnaces, F F, are placed in the basement, and are supplied with cold air through the channels *b b*. The currents of heated air pass from the vertical flues in the walls, and are delivered at the points *a a*. Cold air can be admitted as desired by "cold-air valves" at *c c*. The currents of air pass from the rooms and are delivered to the central shaft, in which there is placed a small stove, to create a strong upward current in the tubes. The plan of admitting cold air to mix with the hot air delivered at the points *a a*, has been found to answer exceedingly well. The original building being badly ventilated, the difficulty of getting the foul-air tubes within the walls was obviated by carrying up large wooden boxes from the floor of each story to the attic, where they joined a metal tube 3 feet in diameter. As will be observed from the diagram (fig. 26, Plate XXXIII.), there are openings into the foul-air tubes both at top and bottom. This plan is found to possess advantages, as the air can be withdrawn from both together, or separately, as desired. Fig. 23, Plate XXXIII., illustrates the arrangement for warming and ventilating schools, as recommended by the Boston committee, appointed to investigate into the subject. The cold-air channel *a* is supplied with air from the vertical flue, which is provided at the extremity with a moveable cowl, or turn-cap, the air being supposed to be freer from dust at a high elevation than at a low one. The channel *a* is 3 feet diameter; *p* is the furnace, 3 feet diameter, in a brick chamber 10 feet square, and of which the walls are 12 inches thick; *d d* is the smoke-flue, finished at top with a Tredgold's cap. The heated air from the furnace is passed up the central flue 4 feet in diameter, spreads right and left to branch flues, and passes into the room through the tablets *b b*; the circulation being regulated by registers, the handles of which are placed at *r r*. The ventilating-shaft, 2½ feet diameter, is placed at *e* in the centre of the building, and is supplied with an Argand lamp *c*. The committee state that it is highly important to have a power of some sort within the ventiduct at the top, and they conceive an Argand lamp the best form for this. The writer of the present article has adopted this plan, with decided success, in ventilating a large school-room, the ventilation of which had previously been in a most defective condition. This arrangement is deemed, says the committee, especially important. "In clear, cold weather, when the furnaces are in action, and a current of warm air is constantly setting into one extremity of an apartment, it is not difficult to establish and maintain an ascending exit current from the other end. Moreover, it enters the ventiduct already warmer than the external air. The ventiduct itself becomes warmed, and so the current, once established, perpetuates itself. But when the furnaces are not in operation, nothing of this sort takes place. And yet this occurs precisely in those parts of the year when ventilation in a school-room is most needed, viz., in moderate weather, when it is not warm enough to open the doors and windows, and yet not cold enough to maintain a fire. At such times the stove in the loft, acting directly and powerfully upon the ventiduct, will at all times create an ascending current, sucking the foul air up, as it were, from the several apartments, and thereby causing fresh air to enter from the other extremities. The position of the windows directly opposite the ventiducts gives a special facility for this purpose when the furnaces are not in action. The windows at such times take the place of the warm-air flues in supplying a stream of fresh air." The committee also recommend that the air admitted to the rooms from the stoves should never be of higher temperature than that of boiling water, and that in all cases where stoves are used as the heating media, it is essential that a large pan, for the evaporation of water to moisten the air, should be placed on the stove. The flues, both for the admission of cold and hot air and the withdrawal of the foul, should be of a maximum size, so as to allow of plenty of margin for the regulation of the ventilation, which should be calculated for the largest number of scholars which the apartments are intended to accommodate. The best average temperature for the air in the school-rooms is from 64° to 68° Fah.

20. In figs. 24, 27, and 28, Plate XXXIII., we illustate the mode of warming and ventilating of the Ingraham Primary School at Boston. Fig. 27, Plate XXXIII., shows the arrangement of the cold-air and smoke-flues arranged for the stoves. 1, 2, 3, floorings of the first, second, and third stories; 4, roof; C "A, cold-air flue for first story, which delivers the air from without, under the stove, as shown at C A in the transverse section, fig. 28, Plate XXXIII.; *r r*, cold-air flue for second story, which empties into the box under the stove, at C A, in the second story of the transverse section, fig. 28; *t t*, cold-air flue for third story, which empties into the box C A, under the stove of that story, as seen in the transverse section, fig. 28. These cold-air ducts are 12 by 18 inches *inside*, and are *smoothly* plastered throughout. This is hardly large enough, however. *s s* smoke-flues. These smoke-flues are 8 inches square *inside*, and are smoothly plastered throughout. That of each story commences in the centre of the pier in the room to which it belongs. The pier in which these cold-air ducts and smoke-flues are placed is wider than the piers between the other windows, in order to allow sufficient width to the ducts. It must be at least 6 feet. Particular attention has been paid to the ventilation. The ventiduct for each room is of ample size, and the three are arranged as in fig. 24, Plate XXXIII. 1, 2, 3, 4, floorings of the first, second, and third stories, and attic; 5, roof; *c c c*, ventiduct of first story, commencing in the centre of the pier. Between the ceiling of this room and the floor of the second story this flue is turned to the left, and then continues in a straight line to the attic, where it contracts and empties into the ventilator V on the roof; *d d d*, ventiduct of second story, also commencing in the centre of the pier and turning to the right, between the ceiling of the second and floor of the third story, whence it is continued to the attic and empties into the ventilator. V *e e*, ventiduct of third story, also emptying into V. These ventiducts are made of thoroughly seasoned pine boards, smooth on the inside, and put together with 2-inch screws. Each, as will be seen, is placed in the centre of the room to which it belongs. They are *kept entirely separate from each other* through their whole length, from their bases to the point where they are discharged into the ventilators on the roof. Each is 16 inches square *inside* through its whole length to the attic, where, as will be seen by the diagram, each is made narrower as it approaches its termination till it is only 8 inches in width on the front, the three together measuring 25 inches, the diameter of the base of the ventilator on the roof. As they are contracted, however, in this direction, they are gradually enlarged from back to front, so that each is increased from 16 to 24 inches, the three together then forming a square of 25 inches, and fitting the base of the ventilator, into which they are discharged. The increase in this direction will be better seen in the section in fig. 28, Plate XXXIII., where V V represents one ventiduct continued from the lower floor to

the ventilator; V, ventilator on the roof, into which the three ventiducts from the school-rooms are discharged. This is 25 inches in diameter; *v v*, registers to regulate the draught of air through the ventiducts. There are two of these in each ventiduct—one at the bottom, to carry off the lower and heavier stratum of foul air, which always settles near the floor, and the other near the ceiling of the room. Each of these registers has a swivel blind, fitted with a stay-rod, and may be easily opened or closed by the teacher; *o o*, closets; the ventiduct of each story being in the centre of the projecting pier, affords room for closets on each side in the first story, and on one side in the second story, as shown at *o o*. There are four in the first story, two above and two below the wainscot. In the second story there are two only, one above and the other below the wainscot, the other side of the pier being occupied by the ventiduct of the first story. In the third story there are of course none." In fig. 28, Plate XXXIII., the figures 1, 2, 3, indicate the first, second, and third floors, and 4 the attic; C is the cellar; C A, cold-air boxes opening under the stoves; S, smoke-flue; V, ventiduct opening into the ventilator in the roof; *v v*, ventiduct registers.

21. Where stoves are used, it should be remembered that it is the better plan to have a large stove, containing a large quantity of fuel burning away *slowly*, than a small stove with a small quantity of fuel burning away *quickly*, as the air obtained is much healthier. In fig. 8, Plate XXXIII., we illustrate two arrangements for a stove recommended by Mr. Bishop, Superintendent of Schools. In the first the cold air is admitted at *a*; it passes down along by the passage or channel *r*, then ascends vertically, where it diffuses itself over the top of the outer casing to the stove *d*. It then passes down the spaces between the double walls *t t*, and passed into the air chamber, where it is heated; and from thence passed by the flues *f g*, *h i*, into the school-rooms. By this arrangement—which has worked well in practice—the walls of the stove-chamber are kept cool, and at the same time, the heat which they give off to the air is economized. In the second arrangement, the cold air admitted as before at *a*, passes from *r* at once to the stove-chamber by the openings in the piers *p p*, and also *up* the channels *t t* to the top *s*, from which, when warmed, it passes off by the tubes *f g*, *h i*. The smoke-flue is at *e*; *c* the ash-pit; *m* cold-air flue to supply stove; *j* feeding tube. In connection with the subject of ventilation may be mentioned here the importance of providing ample space for the children, so that no overcrowding can take place. Seven square feet of area for each child is a good allowance, although nine has been deemed advisable by some authorities.

22. *Lighting of the Rooms.*—In Essay First we have alluded to the importance of light as acting upon the health of the inmates of houses. In a school this cheerful as well as healthy influence should be carefully studied. It is worth while to remember the Neapolitan proverb—"Where the sun does not come the physician must." It is a mistaken notion to suppose that the attention of the children will be taken off their studies by sitting in a room well lighted by wide windows; more time, on the contrary, will be lost in making them to sit continuously under the influence of a dreary and depressing light, or rather half light. The objection which may be made to the dazzling influence of the sun can easily be overcome by providing curtains, and outside or inside shutters to modify this. But while arranging an ample supply of light, care should be taken to have a blank wall, on which to hang diagrams and illustrations. This should be behind the platform of the teacher, and it will be well if this wall be towards the north, the teacher looking to the south—where the light should come from—and the pupils so placed that they will look towards the dead wall with their backs to the light.

23. *Interior Fittings.*—The interior fittings of schools vary much in form, construction, and in the mode of their arrangement. The following *resumé* of points to be attended to in designing and arranging fittings may be useful here. It is obvious that the kind of school, and the class for whom it is designed, will modify very materially its furniture and the mode of its arrangement, but there are general principles which regulate, or should regulate, all. Thus, whatever be the age and size of the child, he must be accommodated in such a way that he is not compelled to sit or to remain in any awkward or physiologically bad position. This seems axiomatic enough, and yet it is by no means a difficult matter to note in schools how very much it is overlooked or ignored. For in very many cases the accommodation is made to a uniform standard, regardless of the fact that there is often anything but a uniformity of the sizes of the children. While the seats and desks, then, are to be made so as to be physiologically correct, and fitted for their occupants, they should be so arranged that the pupils may have room to move easily between them, to go to and from his seat with the minimum amount of disturbance to the business of the school, and, on the other hand, so that the teacher may have easy access to every part, and to every pupil, without which discipline, and the necessary degree of supervision, cannot be maintained or given. The essentials of interior fittings are, first, *desks;* second, *seats.* As to desks, it is deemed necessary that the top surface of the desk should be for each pupil 2 feet wide and 1½ foot broad, with a shelf or other convenience underneath to hold books. The top surface of the desk should incline 1 inch in a foot towards the front edge, but the upper edge or part should be flat, and some 3 inches broad. This flat part is for the purpose of placing the pencils, pen, &c., which are prevented from rolling off by a small bead or feather nailed along the front edge of the flat portion. A groove should be made on the back part of the level portion to admit of a slate being passed into it, and which rests upon a projecting ledge nailed on to the back of the desk. In the flat part of the desk a circular opening should be made, into which to drop the inkstand. The shelf placed below the sloping part of the desk should be about two-thirds of its width, and have a slope inwards—to prevent the books, &c., from slipping out—the distance of the shelf from the lower side of the desk being about 4 or 5 inches. There are various opinions as to the height of desks. The following table shows the dimensions which have been pretty generally adopted for eight different classes of pupils, beginning at four and ending at seventeen years of age. The aim has been to secure for each pupil, on an average, a floor space of 24 inches long by 26 inches wide, an open area of 2 or 3 feet round the room, and an aisle 16 inches wide between the ranges of the desks:—

No.	Height from Floor to Front Edge.	Width of the Top.
1	19½ to 20 inches.	11
2	20½ to 21 inches.	12
3	22	13
4	23	14
5	24	15
6	25	16
7	26½	17
8	27½ to 28 inches.	18

The following are the dimensions of desks adopted by different authorities:—

Authority.	Height.		Breadth.		Tops.
	Upper Classes.	Lower Classes.	Flap.	Ink Board.	Slope.
	Ft. In.	Ft. In.	Ft. In.	Inches	
Privy Council, . . .	2 6	,,	1 0	3	1½ in. in the foot.
Battersea Village School, .	2 6	,,	1 5	,,	3 in. ,, ,,
National Society, . . .	2 6	2 0	0 9	3	1 ft. 5 in. ,,
British and Foreign School So.	2 4	,,	0 9	,,	,, ,,
Manchester National School, .	2 6	2 4½	1 1	3	1½ in. ,, ,,

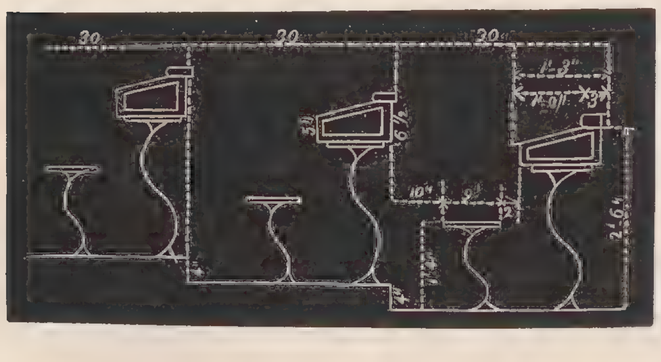
In many schools it is usual to have the desks in continuous lengths; in the advanced organization of schools, however, numerous advantages are said to arise from the plan of having the desks made for two pupils only, the desks to be placed in ranges, but with aisles between them. We now give a few notes on the *seats* or benches. The seat should be of sufficient height for the pupil to have his feet resting upon the floor in an easy position, without any undue strain upon the muscles of the thighs. If benches or long forms are used, the seats should be hollowed out for each pupil. A point which we consider essential, whether in the case of chairs or forms, is that the front edge should be higher than the back edge, thus throwing the slope of the seat from the front to the back. There is nothing which tends so much to comfortable sitting and to ease the muscles as a chair or seat of this sort, and nothing which is so painful as to sit in one made with a slope in the contrary direction. The point here adverted to is worth noting by makers of all chairs, whether school or otherwise. We consider also that an essential point in the construction of a chair or bench is that it is provided with a support for the back. We believe that an immense deal of injury is done to growing children by compelling them to sit without supports for their backs, as well as rests on the floor for their feet. Where children are placed in this unfortunate position, they invariably acquire the habit of stooping forward, and sitting "squat" upon their seats in place of erect. The following shows the dimensions generally adopted for seats, of eight different classes of pupils, from 4 to 17 years of age :—

No.	Height from Floor to Front Edge.	Width to the Support.
1	9½ to 10 inches.	9
2	10½ to 11 inches.	9½
3	12	10
4	13	10½
5	14	11
6	15	11½
7	16½	12½
8	17 to 17½ inches.	12

The following shows the dimensions of forms adopted by the following authorities :—

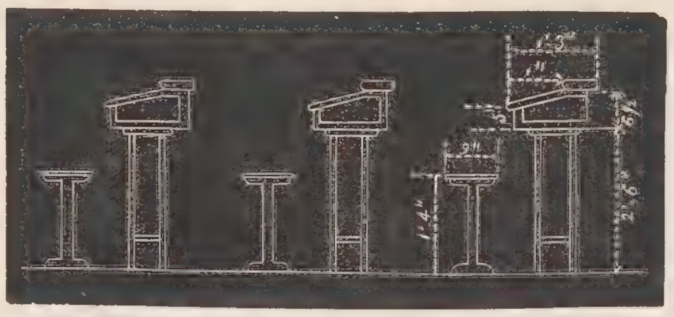
Authority.	Height.		Breadth.	
	Upper Classes.	Lower Classes.	Upper Classes.	Lower Classes.
	Ft. In.	Ft. In.	Inches.	Inches.
Privy Council, ...	1 4	,,	9	,,
Battersea Village School, . .	1 1	,,	8	,,
National Society, ...	1 6	1 2	6½	,,
British and Foreign School Society,	1 4	,,	6	,,
Manchester National School, . .	1 4½	1 2½	9	9

Fig. 29.



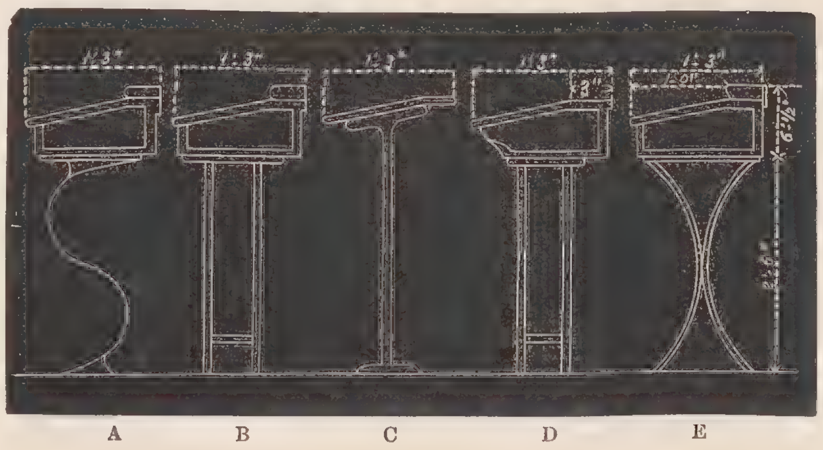
Sections of Desks and Forms on Raised Platform.

Fig 30



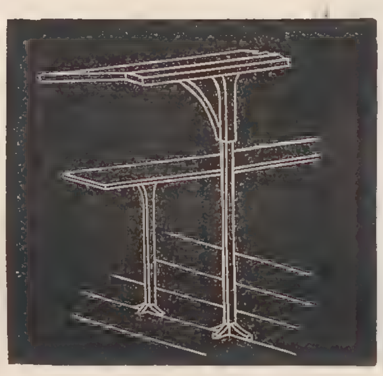
Sections of Desks and Forms on the Level Floor.

Fig. 31.



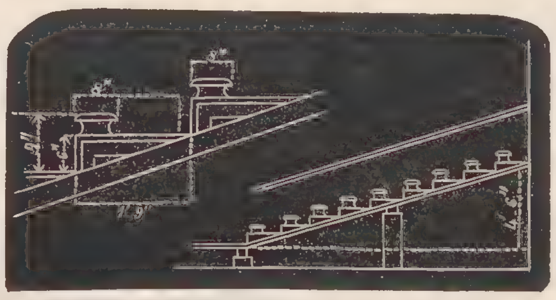
Section showing five forms of Desks.

Fig. 32.



Battersea School Desks and Forms.

Fig. 33.



Infants' Gallery.

24. We give now illustrations of various fittings. In figs. 29, 30, 31, 32, 33, and 34, we give illustrations of school furniture as recommended by the Privy Council on education. In fig. 31 A and E represent desks with iron standards; B a desk complete with clamped flaps and 2-inch butts; C is a simple desk; and D a desk with shelf only. In fig. 32 we give a part view of the Battersea school desks and forms, of which the following are particulars as to sizes :—

Height of first desk, ...	24½ inches.
Height of second desk, ...	27⅜ inches.
Height of third desk, ...	27½ inches.
Breadth of the place for inkstands on each desk, .	3¼ to 3¾ inches.
Breadth of the lap of two first desks, . .	8½ inches.
Breadth of the lap of three first desks, . .	8¾ inches.
Inclination of first lap, ...	1½ inch.
Inclination of second and third lap, . . .	1 to 1¼ inch.
Distance when lap is down, ...	29½ inches.
Distance when lap is up, ...	18 inches.
Thickness of plank, ...	1¼ inch.
Length of desks, ...	9 feet.
Height of seats, ...	15 inches.
Breadth of seats, ...	6½ inches.

In fig. 33 we illustrate the gallery for infants, with part to the left, to a larger scale, showing dimensions. In fig. 34 we illustrate the master's desk and stool. The desk is to be of inch deal, with clamped flap and beaded frame, and fine cupboard lock. The

ON BREWERIES, GAS-WORKS, MILLS, &c.

1. *Section First, Breweries*—illustrated in Plates XXIV. and XXV.—Many and important are the different objects demanding serious consideration in the economy of brewing on the large scale; the mere mashing so many quarters of malt, and converting the product into ale or beer, is a simple matter, and in former days was solely accomplished by means of the most primitive household utensils. Such a system, however, was found incapable of supplying the great demands of the market, and now we find brewing conducted on a most extensive scale, the primitive methods having been only retained for producing small quantities for domestic and limited consumption. The two grand objects to be considered, therefore, in the design of an extensive brewery, is—First, economy of space, and also of primary cost; and secondly, an arrangement by which all operations can be conveniently carried out by the practical brewer, and with a minimum cost of labour and materials. In order that the engineer or architect may be able to accomplish this most effectually, he must possess a moderate knowledge of the various principles upon which the different operations of brewing is conducted; without this knowledge, the brewery passing from his hands, although in an engineer's opinion a model of construction, might, when worked by the practical brewer, be considered most imperfect in its arrangement. It need not, therefore, be matter of surprise for the reader to learn that most brewers prefer arranging their own brewery, or at least having their own ideas carried out; hence their breweries generally answer the purpose well, although, in an engineering point of view, construction is obtained in a very round about way, and with anything but economy. Before, therefore, proceeding to describe the arrangement of the brewery illustrated, we shall endeavour to point out the principal requirements involved in the various operations of brewing.

2. The process of malting the grain is one with which we have little to do in the present case, the brewery not including malting barns, &c.; suffice it to say, however, that the whole operation is a simple one, being that of steeping the malt in troughs, or couches, spreading it upon a floor for a certain time, and then subjecting it to the heat of a kiln, that is, a building having a perforated floor, on which the damp grain is laid, and being heated from below by means of a coke fire. When the malt kilns are close to the brewery, the malt is conveyed in "Jacob's ladders," or "Creepers," consisting of buckets attached to a leather belt, and revolving on two pulleys or screws, having deep and coarse pitch-blades, the malt being deposited on the malt-floor or barn. From this point commences the operation of brewing. The first operation is that of mashing, which is simply a process of infusion; before this, however, is done, the malt requires to be bruised, so as to open the grain; this is usually performed by allowing it to pass between smooth rollers, so as simply to crush it, and thus break the husk which, in its ordinary condition, would protect the grain or malt from the action of the hot water.

3. It may be as well here to notice a process lately proposed by an eminent brewery engineer, Mr. Davison, C.E., upon which a paper was read by that gentleman before the British Association at Newcastle. His process was a preparatory one, and consisted of decorticating the malt previous to mashing—in other words, rubbing or grinding off the husk in a similar manner to that employed to prepare barley for household purposes. This process effects a considerable saving, besides improving the quality of the wort, as in every quarter of malt mashed three-fourths of a barrel of wort are retained by capillary attraction in the spent husks, &c. After the malt is crushed or decorticated it must be conducted to a convenient place near the "mash tuns," as it is there "mashed," or infused; the "wort," or infusion, is then drawn off into what are termed "underbacks," these being simply intermediate vessels between the straining of the malt and the pumping of such into the "coppers."

4. The next process is that of boiling the worts in vessels, which are usually made of copper, hence their name; the hops are here introduced, and boiling continues till the proper specific gravity of the wort is obtained, which is determined by the sacharometer. The "wort," after having been boiled with the hops, is now ready for the fermenting tun, but being at a temperature of 212°, must be reduced to 55° or 60°, and therefore it is allowed to flow out of the coppers into "straining backs," and thence into flat open coolers, the cooling being frequently accelerated by means of horizontal fans and sometimes a refrigerator. Having been reduced to the proper temperature, the wort is allowed to flow into the "fermenting tuns," or squares, where it undergoes fermentation. Under this process the greatest care and watchfulness is required on the part of the practical brewer, and the temperature requires to be nicely adjusted by means of hot and cold water, which will be afterwards explained. The wort having become thoroughly fermented, has now become ale, and being too new or brisk, only requires to be run off into large squares, where it is left to stand for a certain time in order to flatten it previous to finally casking it. Throughout the whole operation of brewing the most scrupulous cleanliness requires to be observed, and for this purpose the different vessels require to be steamed and cleaned out with hot and cold water, thus necessitating a plentiful and convenient supply to each vessel.

5. Having thus briefly described the various operations in brewing, simply in so far as it is necessary to render what follows intelligible—for we do not profess the art of practical brewing—we shall now consider the construction of the brewery illustrated in Plates XXIV. and XXV. The build-

ing is shown in front elevation plans and longitudinal and transverse sections, the dimensions of most parts being shown in the drawings.

6. In the order in which the various operations are performed, we shall direct attention first to the malt floor; this, it will be observed on reference to the longitudinal section, Plate XXV., occupies a portion of the upper floor of the building immediately under the water-tank. The floor, upon which there is a considerable weight, is supported by a wrought-iron girder (No. 2) extending the whole way across the building, the joists resting upon the lower flange; fig. A, Plate XXXVIII., represents a section of this girder, the length being 32 feet from end to end, 1 foot resting on each wall, thus leaving the clear span 30 feet. The breaking load (distributed) of this girder is 119 tons; according to Mr. Fairbairn's formulæ (constant 140) this being quite 4 times the greatest load which can be brought to bear upon the floor; a continuation of this floor forms the hop-store, and also supports the "liquor boiler;" the "grist-box" occupies a portion of the malt-floor, and the wrought-iron girder, No. 3, while supporting the ends of the joists upon its lower flange of the malt-floor, carries the joists of the hop-store and cross girders, sustaining the liquor boiler upon its lower flange. Fig. B, Plate XXXVIII., illustrates a cross section of this girder, its linear dimensions being also 32 feet, taking a bearing of 1 foot upon each wall, and having also a clear span of 30 feet, the breaking weight (distributed) being 161 tons, in this case also having a factor of safety equal to 4. The "liquor boiler" is of wrought-iron plate, ¼ inch thick, having a cubic capacity of 1,575 feet, or 9,815 gallons; it is supported upon 5 wrought-iron girders, No. 4, the section of each being shown in fig. C, Plate XXXVIII. The extreme length of them is 17 feet, 1 foot bearing upon the centre wall of the building, the other end resting upon the bottom flange of girder No. 3, fig. B, Plate XXXVIII., the distributed breaking load being 48 tons. The grain is elevated to this floor by means of the hoist A, shown in the longitudinal section, Plate XXV. This is worked by a line of shafting, also shown, which is driven by a pulley B from the shafting beneath; the winding barrel is geared to the shafting in the proportion of 2 to 1, the speed at which it is worked being 50 revolutions per minute; the chain is led over a jib projecting from the wall, and commands waggons and carts in the yard, as shown in front elevation. At the one end of the malt floor a hopper, communicating with a bruising mill, is placed, shown at C, the mill standing on the lower floor at D (longitudinal section and plan); the rollers are driven from the shafting overhead, being geared by a belt, in the ratio of 2 to 1 from the shafting, the speed of rollers being 200 revolutions per minute, their diameter being 14 inches by 26 inches long.

7. The malt, when bruised, is known by the name of "grist," and is now ready for the mash-tun; for this purpose a tapered box is placed above the mash-tuns, so as to enable the grist to gravitate into the tun, or mashing machine. From the bruising-mill the grist is taken up by means of elevators, as shown at E, consisting of a series of white iron buckets, attached to a leather belt, which revolves over two pulleys, one being actuated by the rollers, so that as fast as the malt is crushed, it is removed by the elevators into the grist-box. The lower extremity of the grist-box is fitted with a sliding door for regulating the supply of the grist to the mashing machine, to which it is connected.

8. *Mash-room and Utensils.*—Formerly mashing was performed by large oars, even in large establishments; they were then superseded by machinery, which, although it answered the purpose of the oars on the same principle, yet it was complicated, and was difficult to keep clean—a matter of so essential importance in all the operations of brewing. Lately, however, all this cumbersome machinery has been entirely superseded by a small and simple machine, by which the "liquor" and grist are kept in a state of agitation at a high speed, in a pipe having a central shaft, with several spokes of round iron attached at its periphery, this running at a high velocity, and thus bringing the "liquor" and "grist" into thorough close contact. This machine is known as Steele's patent, Mr. Steele being a practical brewer and engineer of great ability in Glasgow. The mash-tuns are shown in plan and section at F, and consist of two circular tuns, composed of oak staves 2¼ inches thick hooped together; a false or straining bottom is placed 6 inches from the real bottom of the tun, and perforated with small holes tapering or counter sunk towards the bottom of the tun; the diameters of the holes are about ⅛th of an inch. The mash-tuns are supported upon five cross girders, 33 feet extreme length (No. 8), one end taking a bearing of 1 foot upon the central wall of the building, while the middle and the other end is suspended by means of bolts to the lower flange of two transverse girders (No. 7), thus dividing them into two 15-feet spans. A section of No. 8 girders is shown in fig. D, Plate XXXVIII., their distributed breaking load being 15 tons. No. 7 girders run across the building, carrying No. 8 girders suspended to their bottom flange, while the joists of the mash-room floor rest upon the upper flange; No. 7 girders are of a similar section and breaking weight to that of No. 3 (fig. B, Plate XXXVIII.).

9. Between the mash-tuns Steele's mashing-machine is placed at G, being driven by a belt from the shaft above at H. The relation of the pulley on the shaft to that on the mashing-machine is 2 to 1, the speed of the mashing-machine spindle being 200 revolutions per minute. Attached to one side of the barrel of the machine is the liquor-pipe at *h* (plan), having a cold-water branch joining into this pipe and coming from the main at *h′* (plan and section); regulating-cocks are attached to each, and a thermometer is attached to the pipe beyond the branches, and just before the liquor enters the barrel of the mashing-machine. A bent nozzle is attached to the end of the mashing-machine to lead the liquor and grist into either tun, it being arranged to swivel. After the wort has been run off the mash-tuns into the underbacks, the remaining malt or grist is sparged with liquor at a higher temperature; this is effected by means of a copper pipe *k′*, 2½ inches diameter, being poised upon a centre similar to that of a compass needle; the pipe has a bell-mouthed funnel at its centre, into which the liquor or hot water is run from the branch *k*. A series of holes are perforated in the pipe at opposite sides, so that by the reaction produced by the water when spurting out against the atmosphere, the pipe turns round rapidly and distributes the liquor uniformly over the surface of the malt. It is sometimes required to send the worts from the underback in place of to the coppers into the sparging-pipe; this is effected by opening the valve-cock *l*, and admitting the wort into the pipe *k*. The first "liquor" for mashing has a temperature of from 140° to 160°; each successive sparging, however, has its temperature increased until reaching 190° to 200°. In sparging the worts which are pumped up from the underback, they, of course, being, perhaps, so low as 120°, require additional heat; this is obtained by the worts on their passage to the sparging-pipe, the vertical or stand-pipe being jacketted with high pressure steam from the boiler. The diameter of the wort or sparging-pipe is 2½ inches, that of the steam-jacket pipe being 8 inches, being supplied by the branch steam-pipe, shown in the plan, 1¼ inch diameter, joining the main steam-pipe at *i′*, and being regulated by the valve-cock *i*. A thermometer is placed on the top of the stand-pipe to ascertain the temperature of the wort just before entering the sparging-pipe. By this means, then, any extra temperature may be communicated to the wort or liquor, as the case may require, previous to its being

sparged over the malt or grist. In the mashing-machine the liquor in the liquor-boiler is usually kept a little higher in temperature, and this is reduced by means of the cold-water pipe to the required temperature. The wort is allowed to flow from the mash-tuns into the underbacks by opening the valve-cocks, shown in the plan at *m* and *n*, these cocks communicating with pipes leading to the underbacks.

10. *Cellar, or Underback Floor, with Utensils.*—The underbacks are large square wooden vessels, having a capacity of 2,193 gallons each, the sides and bottom being $2\frac{1}{2}$ inches thick, made up of white pine planks, this being not only the cheapest, but the wood which answers the purpose best. The planks should be tongued and grooved, and properly fitted; and on no account should white lead or any other cement be used to ensure their joints being tight. The wort is raised from these underbacks by means of a centrifugal—by preference, Gwynne's patent—pump. The suction branch of this pump communicates with either vessel, each having a valve-cock. The pump is driven from the shafting, as shown in the longitudinal section at K, at a velocity of 600 revolutions per minute, the ratio of the pulleys on the shafting and pump being 6 to 1. This shafting is carried through the joiners' shop, where it drives a turning lathe, as also a circular saw, the former for turning bungs for the casks, the latter for the use of the cooper for cutting up staves, &c. The speed at which the shaft runs is 100 revolutions per minute, being driven direct from the engine, to which it is coupled by equal 2-feet driving-pulleys, and a leather belt 4 inches broad. The engine-room occupies a corner next the boiler, and the engine is of the horizontal description, having a cylinder 10 inches diameter, and a stroke of 18 inches, making 100 strokes per minute, or 300 feet piston speed. The steam pressure is from 30 to 40 lbs. per square inch, and with this the engine will exert about 15 horse power; nominally, however, the engine is reckoned at a commercial 10 horse. The foundation of the engine is of stone, 3 feet by 3 feet, by preference in solid blocks, the bed-plate of the engine being bolted down, the bolts passing through the blocks, holes being left below for the purpose of introducing cast-iron washer plates, 6 inches square, and inserting cotters into the bolts. The crank-shaft has one bearing upon the bed-plate, while the other is carried in a cast-iron wall-box, built into the wall. The steam-pipe is fitted with a starting-handle, close to the valve-chest, for regulating the supply of steam to the engine (*r* longitudinal and A B line section). At the upper part of the steam-pipe, close to the wall, another valve is placed (*s*, A B section); this is worked by a rod running along the wall, and geared to a vertical rod by a pair of mitre wheels at *c* (mash room plan). The vertical rod passes up to the top floor, or "copper-head," shown at *c′* (cooler plan); on each floor a wheel, 9 inches diameter, is keyed to the vertical rod, 3 feet from the floor, so that the steam to the engine may be regulated to any speed required, or in the case of emergency, the engine may be stopped without the necessity of going to the engine-room. The exhaust-pipe passes from the engine upwards and along the wall immediately under the malt-floor, shown in dotted lines in that plan entering the liquor boiler, through which it takes a circuitous path, rising from thence upwards and passing through the cold-water tank, over which it turns. The exhaust-pipes, on being fitted up, must, where they lie horizontally, have a fall of not less than 1 in 300 towards the engine-room, where the exhaust-pipe descends into the drain, having, however, a syphon trap to check the escape of steam, simply allowing the condensed water to flow into the drain. In this way the whole of the heat of the exhaust steam is utilized in heating liquor for mashing—a matter of considerable importance, although one to which the attention of many brewers is not directed. Lately, indeed, the writer directed a large liquor boiler of similar size to the one in the drawing, which was heated at the expense of 3 tons of coals per week, to have the exhaust-pipe of the engine, in place of being blown into the air, passed through the liquor boiler, where it is now perfectly condensed, and the furnace never lit except upon extraordinary occasions, thus saving fully £50 per annum. The floor of the cellar is paved with bricks, laid in concrete, and upon edge, the depth of concrete being about 18 inches.

11. The brewery shown in Plates XXIV. and XXV. may properly be divided into two sections, the one we have just considered, namely, from the malt-floor down to the basement, all on one side of the party wall. In this section it will be observed that the malt is converted into wort in its passage from the malt-floor down to the underback, at which point we have arrived; following now the wort-pipe from the delivery of the centrifugal pump we find the course it takes to be under the mash-tun floor, as shown in plan at *t*, the pipe *c* being laid along to the party-wall at *t′*, when it rises up the side of the doorway to the coppers (shown in cooler plan and longitudinal section at *t′* and *t″*), turning over by a swivel nozzel into either copper.

12. "*Copper*" *Floor,—or usually known as* "*Copper-head,*" *with other Utensils.*—The coppers consist of two large hemispherical vessels, by preference so on account of the ease with which they are cleaned, the thickness of the copper being from $\frac{1}{16}$th to $\frac{1}{8}$th of an inch according to the durability required; the thicker they are, the longer, of course, they will last; they, however, never exceed $\frac{1}{8}$th of an inch thick. The contents of each copper are 2,022 gallons, that is, the contents at which the worts may be boiled without frying over. The coppers are heated by high-pressure steam, passed into the space formed by the real and a false bottom, or jacket; this jacket is of copper, $\frac{5}{16}$ths of an inch thick, as is also the real bottom of the copper, the latter being stayed by T ribs being riveted across it to prevent the pressure of steam from indenting any part. Steam is supplied from the main steam-pipe by the branch pipes, $1\frac{1}{2}$ inch diameter, as shown in the plan, the supply to the coppers being regulated by the valve-cocks, with wheels marked A A.

13. The condensed water from the bottom of the coppers is led through independent syphon-traps, V V, shown in the section in line C D, the steam jackets of the coppers being shown at U U. From the traps the condensed water is led away by the waste-pipes *w w w w*, which pass under the fermenting-tun floor, and join the main waste-pipe from the vats.

14. The coppers are supported upon three wrought-iron girders (No. 5, fig. E, Plate XXXVIII.), the extreme length of each being 15 feet 6 inches, one end of these girders taking a bearing of 1 foot upon the wall, as shown, and the other upon the transverse girder No. 6, fig. F, Plate XXXVIII. The clear span is 14 feet, and the distributed breaking load 56 tons, the factor of safety being in this case also four times the working load; a section of this girder is shown in fig. E, Plate XXXVIII. The transverse girder, which supports the ends of the girders No. 5, fig. E, Plate XXXVIII., runs transversely across the building, having a bearing of 1 foot upon each wall, and a column supporting the centre; thus, the extreme length is 32 feet, and the clear span is 15 feet on one side of the column and 14 feet on the other, the breaking load of each span of this girder is 54 tons in the centre. Fig. F, Plate XXXVIII., shows a cross section. The coppers have two valve-cocks, $2\frac{1}{2}$ inches diameter, attached immediately under the strainers; these consist of circular discs, 18 inches diameter, $\frac{1}{8}$th of an inch thick, and closely perforated with holes $\frac{1}{16}$th of an inch diameter; they are secured to the bottom of the coppers by six screws to prevent their rising with the agitation of the wort in boiling.

15. The coolers are composed of square iron plates, 2 feet

square, having flanges, 2 inches deep, turned downwards, and being secured to one another by 3$\frac{3}{8}$-inch diameter bolts. The joints are made with rust, or other metallic cement. The coolers are divided into two divisions, a high and low level, each having a fall of not less than 1 in 250 towards the end of the building. The cooler-plates are supported upon wooden joists, as shown; four horizontal fans are driven from the shaft below at a speed of 200 revolutions per minute, the shaft running at 100 revolutions per minute, the relation of the bevil-wheel gearing being 2 to 1 from shaft to fans. The diameter of the fans is 6 feet, the blades being 14 inches broad by 2 feet long, and set at an angle of 56° with the horizon.

16. In some of the latest constructed and most improved breweries the coolers have been of copper; this, however, is more expensive than iron, although much cleaner; refrigerating is also used in conjunction with the coolers to accelerate the cooling, which cannot be accomplished too quickly, as an acetic fermentation—known among brewers as "foxing"—goes on during cooling. Immediately opposite the coppers the liquor-boiler is placed, which is supported by girders already described and illustrated. The liquor is heated by means of the exhaust steam from the engine; when, however, this fails to give the proper temperature, a hand steam-pipe, which is connected to the front of the boiler, injects a jet of steam from the boiler, and, being condensed, imparts its heat to the water. A thermometer is attached to the front of this boiler to indicate the temperature, as also a float to indicate the water level; a branch from the main water-pipe at *y* (longitudinal section, Plate XXV.) supplies the liquor-boiler, being rendered self-regulating by means of a ball-cock, the ball of which is under control at the front of the boiler by means of a chain passing over two pulleys, as shown. The main liquor-pipe is of copper, $\frac{1}{16}$th of an inch thick and 4 inches diameter, and is regulated at the boiler by the valve *z* (longitudinal section), the pipe passing down the wall to the mash-tun floor; these branches are taken off to the mashing-machine and sparging-pipe, as also others which will be noticed afterwards.

17. Returning to the coolers, we remind the reader that we stated the fall of these was towards the end of the building; close to the wall, in the end plate, are three plugs, marked L M N; these communicate with separate pipes, each having a plug; the pipe L is the wort-pipe, leading to that which passes along the cast-iron girder under the fermenting-room floor, having its respective branches to each fermenting square. The pipe M leads into the drain, being a waste water-pipe used in cleaning out the coolers. The pipe N leads into the end vat, into which it is intended to convey the sweeping or the remainder of the worts, which is afterwards filtered and added to the rest in the fermenting squares.

18. The wort-pipe will be readily distinguished from other pipes shown in the drawing by its wave-line in the centre. This pipe is made of copper, $\frac{1}{16}$th of an inch thick, 3 inches diameter, running under the floor the whole length of the fermenting mass; a branch pipe, 2$\frac{1}{2}$ inches diameter (copper, $\frac{1}{16}$th of an inch thick) communicates with the bottom of each fermenting square, each pipe being fitted with a valve-cock, the wheel of which projects above the floor of the tun-room, as shown in plan and longitudinal section at *d d*, or in pairs, one to each tun. At the wall next the mash-room, where the steam-pipe branch ascends to supply the coppers, a small cross branch, shown in plan at *e*′, joins the wort-pipe, being regulated by a valve-cock *e*; this is for the purpose of introducing a jet of steam to cleanse the pipe, or any of the fermenting squares, by opening their respective cocks. The valve-cock next the one regulating the steam to this pipe communicates with the liquor-pipe branch which supplies the mashing-machine, this being for the purpose of washing out the wort-pipe and fermenting squares with hot water. There is a fall upon this pipe towards this end of 1 in 200 for the purpose of emptying itself into the flattening squares. The communications to these vessels for the wort, when sufficiently fermented, is by the pipes S S S (plan and longitudinal section, Plates XXIV. and XXV.), which have valve-cocks carried up to the floor of the tun-room. At the other extremity of this wort-pipe a communication is made with the cold-water pipe for purposes of cleaning a cock P regulating the supply. The other valve R opens a communication, when required in cleaning, with the waste-pipe, which carries off all waste products into the drain; thus, the wort-pipe, while serving as a channel for the conveyance of wort from the coolers to any of the fermenting squares, also serves as a cold, hot water, steam, or waste-pipe, for any purpose requiring a supply of such to the squares.

19. The fermenting squares are made of white pine wood, 2$\frac{1}{2}$ inches thick sides and bottom, jointed similarly to the underbacks. Each square has four coils of 1-inch copper pipes for the circulation of hot or cold water, either being used according as the temperature of the fermenting wort may require to be raised or lowered. The entry pipes are marked in the plan and longitudinal section *q q q*, &c., which are branches from the supply-pipe, which runs on the opposite side of the cast-iron girder to that on which the wort-pipe is laid; at each end are communications with hot and cold water, that for hot water being at *f*, next the centre wall, the cold water valve-cock being at the other extremity. A waste-pipe runs alongside of the wort-pipe in communication with the drain; this pipe receives the exit-pipes from the tuns, which are shown in the plan and longitudinal section at *p p p*, &c. This floor is supported on cast-iron girders, 18 feet 9 inches long; these are arranged in line, as shown, being bolted together at the tops of the columns; the two end girders take a bearing of 1 foot upon each wall; the breaking weight of each span is 72 tons distributed load according to Mr. Fairbairn's formulæ, and with a constant of 50; a section of this girder is shown in fig. G, Plate XXXVIII. The brewery is covered partly by the tank, hereafter described, and over the coolers by an iron roof, as shown. A detailed plan of the roof is shown, having the sizes of the various parts marked. The method of covering the roof is by fixing along the principals angle irons 1$\frac{3}{4}$ inch by 1$\frac{3}{4}$ by $\frac{1}{4}$ inch. These are bolted to the T-iron rafters, at vertical distances of 12 inches apart, if for Queen's slates. The slates are secured to the angle irons by means of copper nails, which are bent round and turned over the lower flange. The tie-rods are keyed up with double jib and cotter in a cast-iron shoe, which takes the end of the rafter and forms a bed-plate for the wall, to which it is secured. A smaller roof, of a simple character, is placed over the cooperage, smithy, and stables, also of iron. The boiler is covered with curved corrugated iron sheets, No. 16 wire gauge, simply secured to the side walls without tie-rods or rafters.

20. The brewery is supplied with cold water from the tank, which is placed upon the top of the building, as shown. The tank is of cast-iron, the plates in the bottom being $\frac{3}{4}$ths of an inch thick, and those in the sides being $\frac{5}{8}$ths of an inch. The manner in which they are bolted and stayed is shown in detail in Plates XXVII. and XXVIII. in the companion work, "Working Drawings in Engineering and Machine Making." It is supported on three wrought-iron girders (No. 1), a section of which is shown in fig. A, Plate XXXVIII. The breaking load distributed is 180 tons, giving a factor of safety of 4, a large proportion of the weight of the tank being carried by the side and end walls of the building. The exhaust-pipe from the engine passes through this tank, so that sufficient warmth may be given to the water, simply to keep it above freezing point in winter. The tank may be supplied either from a high-pressure town main or from a well, in the latter case being

pumped out by the engine. The brewery is supplied with steam at from 35 to 40 lbs. per square inch pressure, by a double flue boiler, 25 feet long, each flue being 3 feet 6 inches diameter. The outer shell-plates are of Stafford Best Best H, or equal quality of iron, $\frac{7}{16}$ths of an inch thick. The flue-plates are of Lowmoor or Bowling iron, $\frac{1}{2}$ inch thick. The ends, which are flat, are also of the same quality and thickness of iron as that of the flues. The ends are attached to the outer shell and flues by angle iron rings, $3\frac{1}{2}$ inches by $3\frac{1}{2}$ inches by $\frac{3}{4}$ths of an inch, the ends being stayed by gusset plates radiating from the centre of the shell towards the circumference; gussets, spaced 12 inches apart at the circumference, and composed of $\frac{7}{16}$ths inch plate attached to boiler shell and front plate by angle iron, 3 inches by 3 inches by $\frac{1}{2}$ inch. The boiler is fed either by a feed-pump, driven from the engine, or a Giffard's patent injector—by preference the latter, being more economical, and being entirely independent of the working of the engine, which, in a brewery, is not always at work when steam is required. The yard is furnished with the different apartments, such as cooperage, smithy, stables, cart-shed, gate-house, with weighing machine, cask-cleaning shed, and offices, as shown in the plan. The cask-cleaning shed is furnished with several steam-pipe nozzles, over which the casks may be steamed, as also with hot and cold water taps, to which flexible india-rubber hose may be attached.

21. Having thus briefly described the brewery illustrated in this work, we would observe in conclusion, that not only is the building most completely rendered fire-proof, but on the principle of "prevention being better than cure," there is not, from the nature of construction and arrangement in the practical operation of brewing, a spark of fire required, if we omit the burning of gas or other material for light. This is a most important fact, especially when the accomplishment of such is attended with not only convenience to the practical brewer, but also economy in all the operations requiring heat. We doubt not that the same principle might, with considerable advantage, be carried out in the construction of malt-kilns buildings, so fruitful in causing fires; in place of using the coke fire, burning freely under a perforated floor, might not a coil of high pressure steam-pipes be used, or a floor composed of a casing filled with steam? By such means regularity of temperature could be at once obtained by the regulation of a simple stop-valve. With what economy this would be accompanied we do not presume to say; but the subject of excluding all sources of fire in such buildings is one of immense importance, and with such suggestions we leave it to those more directly engaged in the operations of brewing than we are.

22. *Gas-Works.*—In Plate XXVI. we have illustrated, and in Essay Fifth we have described, a Three Retort Gas-Work, in which the leading features connected with the establishment of a gas-work are briefly detailed. It remains, therefore, for us here to glance briefly at some of the points not alluded to in the Essay named above. And first, as to the *site of the works.* Just as in former times, when water carriage was the most economical, gas-works were built near a canal; so in the present time, the best site for a gas-work is near a railway. From this a "siding" can be taken, along which the fuel, &c., can be easily transported to the works as required. It will result in a large saving, both of money and time, if the level of the railway is above that of site of the gas-works; for in this case the branch rail or siding can be carried along at such a height as to give the utmost amount of facility for "tipping" the coal in the immediate neighbourhood of the retort house. It is almost needless to point out the importance of having the site for the gas-works dry, and as free as possible from all risk of flooding by the overflow of rivers, canals, &c. Further, the position of the site of the gas-works, relative to the town or place which they have to supply, should be such, that the gas-works are at a lower level than the houses; as by this arrangement the acensive power of the gas is availed of, and it will be, on the whole, delivered in a purer state than if it is forced to descend from the works to the town. It forms no part of the design of this Essay to refer to the laying down of the mains, but it may be permitted its writer to hint at the vital importance of having the whole district mapped out and the levels taken. A little care taken in this direction, and a little money expended at the first commencement of the works, will result in a large saving in the end. The soil of the site is of importance, and should be carefully attended to, remembering the excavations necessary to be made for the gasometer, and the foundations of the several works connected with the establishment, as chimney-retort house, walls, &c., &c.

23. One of the most important works connected with the gas-works is the excavation for the gasometer. Of late iron plates have been used for the lining of the sides of the excavation; but brick is, on the whole, the best material to use for this purpose. When this is used, the pit is usually made of such a depth that the upper edge of the tank is not much above the level of the ground,—sometimes, indeed, on the same level. Ample space should be left behind the brickwork forming the tank, for clay puddling, which must be most carefully rammed in. This puddling, in certain soils, is often given to the bottom of the excavation; much, however, will depend upon the nature of the soil, as to whether this bottom puddling is required or not. The thickness of the puddling, and of the brickwork of the tank, will also obviously depend upon the nature of the soil. For a tank 100 feet in diameter, Mr. Hughes allows a thickness of puddling of 6 feet 9 inches at the bottom; and of brickwork 5 feet 3 inches. The thickness of the walls or sideworks at the bottom of the excavation is—exclusive of footings—$3\frac{1}{2}$ bricks—which, by offsets, is reduced at the level of the ground to 2 bricks. Mr. Hughes states, that these dimensions are greater than those adopted by the eminent Gas Engineer, Mr. Clegg, who for a tank of 87 feet diameter allowed a thickness of brickwork of 18 inches at the bottom of the lining, and of 14 inches at top. But as Mr. Hughes remarks, the question of thickness of brickwork and of puddling will be decided by the nature of the ground; and whether, also, the use of concrete will be necessitated. In carrying up the brickwork, roman cement or hydraulic mortar must be used. Some contractors deem common mortar good enough, but that this should in no case be permitted, will be obvious when the solvent action of the water—which always fills the tank—on the mortar is remembered. The putting in of the puddle behind the brickwork is a matter of considerable importance; a mixture of clay with sand is better than pure clay alone. Care should be taken to have the puddling material free from pieces of wood, straw, or other vegetable matter, which decaying in process of time will leave hollow spaces, and reduce the consistency of the puddling. The puddling material should be put in of a somewhat thin consistency, so that it may be forced well in between the joints of the brickwork. To secure this and the thorough consistency of the whole, it will be advisable to put in the puddling in comparatively thin layers or "tips"—not exceeding 12 inches. The thickness of the puddling need not be uniform throughout the whole depth of excavation, but have a batter or slope towards the ground; so that in a depth of 25 or 30 feet, the thickness at top or ground level will be one-fourth of that at the bottom. The space behind the puddling—between it and the excavated sides of the ground—which will thus gradually increase in width as it approaches the level of

the ground, should be filled in with well-rammed earth. A very complete specification for a brick tank will be found in Mr. Hughes' Treatise on Gas-Works (31), which forms one of Weale's well-known Rudimentary Treatises, and which is published by Virtue Brothers and Co., London. The reader desirous of studying the whole subject, both as to the construction of gas-works and of the manufacture of the gas itself, will find this work well worth consulting.

24. *Lime-Kilns—Brick-Kilns, &c., &c.*—In Plate VIII. we give, in fig. 1, a *Vertical Section of a Spheroidal Lime-Kiln to be heated with wood.*—A, fireplace. B, inner lining of the kiln of fire-brick. C, general mass of the kiln. D, shed to cover the top of the kiln. E, spherical dome, formed of the larger blocks of limestone just above the flues of the fire-place, to give the flame a freer passage through the body of the stone. F, body of limestone. Fig. 2. *Plan and Section of a Conical Lime-Kiln, for pit-coal or charcoal.*—A, A, annular vault into which the lime is received after being burnt. G G, entrances to the annular vault. B, general mass of the kiln. C, small spherical vault, with flues at top to supply air to the combustible. D, conical nucleus of stone to facilitate the passage of the burnt stone into the openings made in the annular vault. E, small parapet wall round the top of the kiln. F, body of limestone and combustible material.

25. Fig. 3. *Plan and Section of a Kiln for burning clay for Cement.*—A A, fireplaces. B B, oven in which the clay is burnt.

26. Fig. 4. *Elevation of a Mortar Mill.*—A, circular trough for the reception of the materials. B, wheel running in the trough to mix the materials. C, axle of the wheel to which a horse is attached. D, verticle axle which receives the axle of the wheel. Fig. 5. *Section of an ordinary Mortar Mill.*—A, vertical axle which receives the raks. B, horizontal arm to which the horse is attached at the hoop C.

27. *Bricks* are burnt in one of two ways—(1.) in clamps; or (2.) in kilns. In clamping, the bricks are piled one upon another, and the peculiarity of this mode of burning the bricks is, that "each brick contains in itself the fuel necessary for its vitrification; the breeze or cinders serving only to ignite the lower tiers of bricks, from which the heat gradually spreads over the whole of the clamp. No spaces are left between the bricks, which are closely stacked, that the heat to which they are exposed may be as uniform as possible." For a full description of the method of clamp construction and burning, see the Rudimentary Treatise (Virtue Brothers and Co.), on "Bricks and Tiles," by E. Dobson. Bricks are most generally burnt in kilns, the forms of which are very numerous. A very simple form of kiln is made by enclosing a space with four walls; the end walls being provided each with a narrow door-way, through which the inner space is filled with the bricks. The bricks are disposed and built up in such a manner, that openings are left between them reaching from top to bottom; through which the heated air and smoke passes up to the top. These end doors are bricked up when the kiln is filled. The side walls are provided with a series of narrow arched openings; these being placed exactly opposite each other. These side openings are joined by a series of flues of brick, some 8 inches in width, and some two to three feet high. The fuel is consumed in these holes or flues—and the top of the kiln is covered with earth, broken bricks, and boards to keep in and economize the heat. Another form of brick-kiln consists of a chamber, with an arched top, the fireplaces being at the side; the heated air from which passes right up through the bricks, and escapes by the chimneys placed at the top.

28. In the ordinary modes of burning bricks in kilns, it takes from 10 to 13 cwt. of coal to burn 1000 bricks, which makes the cost of burning about 4s. per 1000. It is obvious, therefore, that it is a matter of great importance to economize the fuel consumed in the burning of bricks. It is also obvious that much of the heated air produced in the kiln, and passed away by the chimney, might be economized by using it for *drying* the bricks. Both these objects are secured—and secured, we think, in a very efficient and ingenious way—by the patented arrangements of Mr. Johnson Hands, part of which is illustrated in Plate VIII. Fig. 6 being a section of the "drying room." Fig. 7 of the kiln. The following is a brief description of Mr. Hands' system:—

> "The bricks, when made, are at once taken into the drying-shed, which is a building occupying an area of 150 feet in length by 60 feet in width, this space being allotted to goods in various stages of manufacture, so that the raw material enters at one end and issues from the other perfectly finished and ready for the market. This drying-shed is heated by flues constructed on the plan of Mr. Hands' patent, through which pass all the smoke and waste heat from the kilns. The flues run nearly the entire length of the shed, stand about 7 feet above the floor, and are 18 inches in width inside. They are united at the lower end of the drying-shed, and thus form but a single flue, the waste heat of the two kilns passing up one side of the shed and down the other, consequently making a complete circuit.
>
> "By means of these flues thus raised above the floor, and heated by that which would otherwise be entirely lost, the drying-sheds are kept at a temperature of from 120 to 130 degrees, according as the dampers formed in the top of the flues are opened or closed. Four of these dampers are inserted in the top of each line of flue, and act most admirably in carrying down the moistened air of the shed; a very important point, the air being continually rendered moist by the evaporation from the bricks in course of drying. The dampers can, of course, be regulated at pleasure, according to the state of the weather, the heat required, and quantity of bricks to be dried. As the drying-shed must be supplied with fresh air to take the place of that which is carried into the flues in a moist state, it is brought through pipes passing through the upper parts of the kiln nearest to it, so as to supply nothing but heated air to the drying-shed instead of air at the ordinary temperature.
>
> "Each kiln is large enough to contain 40,000 bricks when arranged with spaces between them, one inch being left all round between the bricks and the kilns, and is fired by three furnaces, the products of combustion passing through the kilns, thence along the flue on one side of the shed, under the floor, thence along the flue on the other side, and so to the chimney which is common to both kilns.
>
> "Mr. Hands, by these simple and natural means, and without any extravagant outlay, utilizes the heat generated in the kilns during the burning of the wares, and at the same time effects the perfect combustion of the fuel, and so prevents the issue of smoke from the chimney.
>
> "His plan also accomplishes the safe, uniform, and rapid drying and burning of the wares by the fuel used for burning, thus effecting the twofold object at the cost of the fuel hitherto used in the burning only. The invention entirely refutes the statement of the old brickmaking hands, that by drying the bricks in a moist atmosphere the inside of the brick is made to dry before the outside—in other words, the moisture of the air keeps the brick from incrusting, and thus allows the moisture from the interior to pass off. These features of Mr. Hands' invention, ensuring a safe, regular, and rapid evaporation of the moisture from the newly made wares, and a large economy in fuel, time, space, and labour, are of the greatest importance, but above all it must be remembered that the whole operations may be carried on at all times, no out-door drying being necessary—the brickfield being converted, as we stated at starting, into a brick factory."

29. *Factories.*—In Plate VIII. we give the ground plan of the factory erected by Messrs. J. and F. Howard (at Bedford), the well-known agricultural implement makers; it is distinguished by several features of novelty of arrangement. The following description of it has been handed to us by the Messrs. Howard, by whose courtesy we are enabled to present the plan in Plate VIII. to our readers:—

> "The entire range of buildings, comprising workshops, offices, stores, sheds, and lodges, together with the implement-yard and wharf, occupy a surface of 15 acres.
>
> "The workshops consist of six bays or divisions; that facing the north includes brass foundry, plate-furnace, flask-store, facings and

mills, sand and blacking store, and tank and boiler-house. Over the boilers is an open floor for drying timber. The iron tank contains 10,000 gallons of water, which is drawn by the engine from the adjacent river, and supplied to all parts of the works and offices. The second roof encloses the foundry, dressing-shop, and pattern stores. The most noticeable feature in Messrs. Howards' foundry arrangements is the extent to which they have carried out moulding by machinery; they produce in this department about 10 tons daily, of quite light castings, the bulk of which are made by labourers, and certainly nowhere can be seen cleaner or more perfect castings. These moulding machines were patented by the head of the firm some few years since, and combine perfect truthfulness and rapidity of production. The Coalbrookdale Company, Messrs. Ransome's, and other eminent founders, are licensed to use this invention. We think a visit to the Britannia foundry would amply repay those interested in the extensive production of castings of one particular pattern.

"In the centre of the third compartment is the engine, enclosed in a handsome glass case. One end of this shop is devoted to grinding, glazing, drilling, and screwing; the other as a lathe and erecting shop for steam cultivators; the ends of this division are walled off—the one part for the pattern-maker's shop, the other is a fitting-shop for the castings, as they leave the grindstones or glazing-wheels.

"The fourth, fifth, and sixth compartments, enclosing more than an acre of land, and divided by two sets of iron columns, comprise the smithery, the bar-iron stores, and stores for finished smiths' work; the outer division being used as a fitting-shop for the final adjustment of the various implements prior to their consignment to the painting-sheds, and there are some very simple and ingenious contrivances for facilitating the production of smith's work, as well as for securing uniformity of make.

"In addition to the railway sidings already alluded to, tramways are laid completely round and through the whole range of buildings, turntables being placed in the centre of each shop, and at other suitable points. The coal and fuel, when landed at the wharf, are taken up in trucks, and weighed out to each workman by others exclusively employed for the purpose; and at stated periods the weight of forgings produced by each smith is compared with the quantity of fuel used.

"The pig-iron is landed on the wharf either by railway or from barges; it is broken up, brought in on the tramways, raised to the cupolas by a steam-lift, melted, and served out to the moulders from a large truck ladle, at a price per ton, paid to the furnace tender, who employs his own assistants, the iron and coke being weighed out to the tender by a responsible man engaged for the purpose.

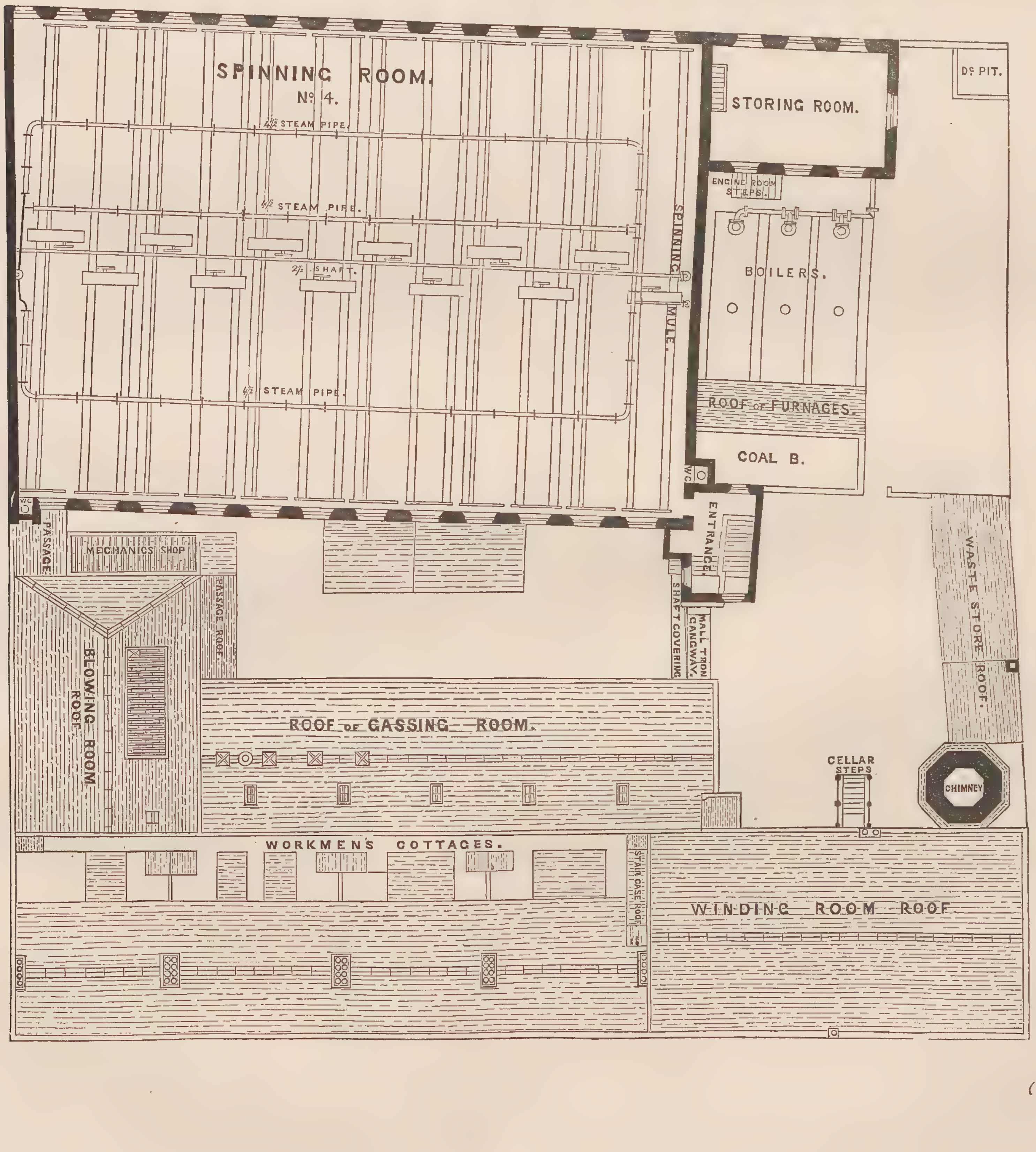
"The bar-iron is brought by rail to the door of the stores, which directly communicates with the smithery; a shearing machine cuts off the iron into required lengths, which is conveyed on the tramways to the respective forges, the person in charge of the shearing-machine being paid by the piece, and made responsible for the scrap.

"Parallel with the workshops, and distant some 60 feet westward, are timber-sheds, carpenters' shops 80 feet by 30 feet, furnished with circular saw-bench, and painting-shed 100 feet by 30 feet. In the paint-shop the colours are ground by a machine, which effects such an immense saving of labour that it is somewhat surprising that it is not more generally used.

"Comprised in the same block of buildings are stables, chaise-house, men's water-closets, urinals, fire-engine house, and other conveniences.

"In connection with the offices, a handsome pile of buildings (the general arrangement of which will be seen on reference to the accompanying plan) is a waiting and reading room, containing the leading agricultural and daily papers, bound copies of "The Engineer," and

Fig. 1.



other valuable agricultural and mechanical periodicals. The buildings we have here described are entirely on the ground floor; the roofs of the workshops are each 52 feet span; the tie-rods, king and queen bolts, struts, heads, and shoes, &c., are of iron; the roofs are covered with buff tiles, which have been found to secure an agreeably cool temperature during the summer months. The light in the shops, excepting the pattern and pattern-makers' stores, is obtained from the roof, in which are inserted 29,000 glass tiles with light iron frames.

"The offices are covered in with green Bangor and Delabole slates in alternate bands. The buildings have been erected with the local red brick in the Italian style, the string courses, archivolts, parapets, &c., being rendered in red, white, and blue bricks in pleasing amalgamation.

"The designs were furnished by, and executed under the superintendence of, Mr. Robert Palgrave, 11, Pall Mall East."

30. In Plate VIII. we give three plans of a "Cotton Spinning Factory," and in fig. 1 (see p. 7) the remaining plan. The lettering on each plan describes so fully the arrangement of the various apartments that we pass on at once to advert briefly to a few of the leading points connected with structures of this kind. As regards the materials employed in the erection of factories in which heavy machinery is placed, Mr. Kennedy has an exceedingly valuable suggestion. While noticing that mills are either built of brick entirely, or of stone entirely, according to the capabilities of the districts in which they are built for supplying either class of material, he points out the advantages which would arise from using a combination of the two in every building. These advantages may be briefly glanced at here. First, the additional architectural or decorative effect produced by making the windows and door-dressings—the cornices and string courses—of stone, while the walls are of brick. Secondly, greater strength would be obtained by having through stones introduced, which would act as "binding courses through the entire thickness of the wall, and that at the point where they are often apt to be weakest." But the most important advantage derivable from the use of stone combined with brick would be having all the parts of the building of stone, to which the pedestals, brackets carrying the shafts, &c., could be fixed, and a much greater bearing surface could be given to them, thus ensuring the higher stability of the structure. Foundations of mills are in many cases of too small an area for the height of the walls resting upon them. This remark applies, as pointed out by Mr. Kennedy, with greater force to the foundations of the iron columns. These are generally made of smaller area than the area of the wall foundations; but this is a mistake, and they should in all cases be made at least of equal area, inasmuch as they have a large weight to carry. It should be remembered when arranging for the foundation of columns, that they are the media "for transmitting the load to the foundation;" that their "load is concentrated on points when compared with the uniform distribution of that under the walls;" and lastly, that "the sinking—even to a very small extent—of any of the columns, causes very serious damage to both gearing and machines." With reference to the use of brick as a building material for mills, the same authority suggests the advisability of reducing the dimensions, so as to ensure greater strength. On this point he remarks:—"It is well known that the majority of them are about $3\frac{1}{2}$ inches thick, some of them more, thus making the height of each course nearly equal to the width of a brick, which not only looks bad, but also weakens the stability of the walls. This weakening arises, not only from the height of the courses, but also from the fact that all the softer bricks are built in the inside, and more particularly in the heart of the walls; and as they are always thicker in proportion to their softness, it is easy to see that this produces the very reverse of what is necessary to constitute a stable building, as the bed joints through the wall, instead of being level, are more frequently round, thus giving the wall a tendency to topple, which is only met by making the lime-beds thicker for the outside course than for the heart of the walls. . . . No one who has seen buildings, in which the bricks are only about $2\frac{3}{4}$ inches thick, and the bed of lime not more than $\frac{1}{4}$th of an inch thick, thus making each course 3 inches thick, but must have been pleased with the decided superiority of their appearance. Such bricks possess, in addition to this, the advantage of being more likely to be evenly burnt, and also of there being much less difference of thickness between the hard and the soft ones, thus enabling the walls to be built with a thinness of bed-joints not attainable at present, although always required in the specifications issued." As regards the employment of stone, Mr. Kennedy has also some remarks of such practical value that we do the reader a service by reproducing them here:—

"If we look first at the suitability of stone for the purpose, there can be little doubt that it is the very best possible, if used in the form known as cube materials; as the bed joints, being all horizontal, there is little if any tendency in the stones to shift; and it is also a very simple process to make the proper arrangement for building in and securing the wheel fixings, or whatever kind of fixing may be required, as stones can be easily brought to the shape required to fit the metal, and bolt holes can be made with certainty in the required position. But if we take rubble or ashlar walls, then the case is very much altered (although in some localities there is no alternative but to build rubble walls, and there are many such buildings, yet it is by no means a system to be adopted if it can be avoided), as the stones are of every conceivable shape, the joints are in very few cases either horizontal or vertical, and even the headers that are intended to strengthen the wall by binding the two faces of it together are seldom anything like square stones, making the wall depend in a great measure for its stability on the cohesive power of the mortar, which takes years to set properly, whereas the machinery is put up at the first, and by its vibratory motion has a powerful tendency to disintegrate the building, and thus prevent the mortar from ever setting in the best manner. And if this be the case with rubble walls, it can scarcely be said to be improved with ashlar, as from the system pursued in preparing the ashlar in the quarries, the stones are reduced to a thickness that makes the wall little else than two thin walls, the one ashlar and the other rubble, held together by the mortar, and the rybats of the doors and windows; no doubt this could be improved by making the ashlar stones more nearly resemble cube work, and the stones for the rubble of such a size and thickness as to work in course with the ashlar, but this would very much increase the cost, which is altogether unnecessary while we can take brick as a building material."

In deciding upon the sanitary arrangements of mills, special attention should be paid to the providing of water-closet accommodation and ventilation. There are many difficulties attendant upon the arrangement of water-closets in public works so as to meet all the sanitary and economical necessities of the case. Where the two sexes work in the same mill, whatever arrangement be adopted, it is essential that separate accommodation be given for each sex. In many cases water-closets are provided entering from each floor, while in others a separate building is provided on the ground level, forming part of the range of buildings. In this case they should be as near the work as possible, and if near the office of the time-keeper or lodge-keeper so much the better, as a degree of supervision is required to overcome the habit of workmen loitering in the place. Further remarks on this subject, and on that of ventilation, will be found in other parts of this work.

OUTLINES OF AGRICULTURAL ARCHITECTURE.

FARM BUILDINGS.

1. To one thoroughly conversant with the various styles or modes of farming carried out in Great Britain, and with the various operations and requirements of each particular mode, it is by no means an easy matter to design the building in which these operations can best and most economically be carried on. There are so many points to be considered, so many peculiarities of operation dependent, not only upon the locality in which the building is to be erected, but upon the notion or caprice, as the case may be, of the farmer requiring it, that much previous study is necessary before the plan can be elaborated, and pronounced, upon careful examination, to be well adapted to the position in which it is to be placed. Nevertheless, judging from the number of so-called "model plans," "prize plans," and the like, which have been introduced of late through the medium of publication, it seems that to many the planning of such buildings is a matter of the greatest facility. From many of these, as we have elsewhere remarked, "it is easy to see that in the opinion of the designers all that it is necessary to know was a series of names of apartments, such as barn, granary, implement-house, stables, cowhouse, and the like; and all that was necessary to do was to put these into a species of designing pepper-box, so to speak, and to dust them over a sheet of drawing paper, taking care to arrange them in somewhat like symmetrical order, so that their outline would give in elevation a decently fair architectural *coup d'œil.* That something like this process has been carried out by some is evident enough, for from the incongruous intermixture of apartments, it has not apparently been considered whether there was a necessity for having all these which they so ingeniously crowded into their designs. It has never struck many of them apparently, that some of the apartments were not at all required in the processes of a certain kind of farming; that in point of fact they were as much out of place for certain purposes as a cotton carding room would be in a worsted or silk factory. The fact to many of them being unknown, that as there are different styles of manufacture, so there are different styles of farming, and that the latter require manufacturing premises, as it were, designed in accordance with their manufacturing peculiarities, just as carefully as do the former." This truth, or principle, here insisted on, renders it impossible, therefore, that there can be such a thing as a "model plan" for a farm building—understanding by this term a plan which will suit all circumstances, modes, and local peculiarities of farming. The plan may be a model, or at least considered as such by the planner, for all circumstances of a like nature with that for which it is designed—that is, supposing it has been designed for some peculiar form of practice. But it is not—nor, indeed, can be a model for all places—and where the term is used it can only mislead. For it is very obvious that a plan of a dairy farm-building cannot be adapted for a pastoral or a mixed husbandry farm-building. A plan may well enough be called a *prize plan*, inasmuch as that title may only indicate the fact that it was deemed worthy of distinction from being well-adapted for a particular or peculiar locality or class of circumstances. But it is subversive of the right meaning of the term to call a plan a *model* one, leading it to be supposed that it is a model for *all* circumstances, however extended, when it may only be adapted for a very limited sphere of operation.

2. In planning a farmery, or farm-steading, then, it is necessary to know two things—first, the kind or mode of farming for which it is designed, so that apartments shall not be given in it which are required for another mode of farming, but not required for the mode under consideration; and second, the manner in which the work of the farm-building is carried on; so that the apartments required will be arranged in such a way that the materials of animal consumption be carried regularly through them, and that no time be lost in unnecessarily carrying them from one and returning it.

3. These two desiderata being attended to will result in attaining at once economy of construction, and economy of labour in the daily work of the farm-building. The first of these, namely, the knowledge of the kind of farming for which the plan of building is required will be of comparatively easy attainment, the client of the architect employed affording him all necessary information on this point. But the second involves many considerations which are too frequently lost sight of by architects. These considerations have been taken up and well expounded by various agricultural authorities, and it is to these we are now about to direct the attention of our readers. On all the points of site, principles of arrangement, dimensions of apartments, and details of construction, many opinions have been given through the medium of the agricultural press during the last 15 or 20 years. But valuable as they are to many, unfortunately they are as a sealed book, from the rare, and, we may say, unpopular works, or little known periodicals in which they are preserved. It will be doing a practical service to our readers if we extract these, or the spirit of these, and present them in some fairly-arranged order for their inspection.

4. The first of the points we shall direct the attention of the reader to, is that of the *site of the building.* On this various agricultural authorities have given their opinion. Possibly what Mr. Stephens, in the "Book of the Farm," has said, exhausts all that can be well advanced on the point. "It is a necessary condition to its proper use, that every steading be *conveniently* placed on the farm. To be *most* conveniently placed, in theory, it should stand in its *centre;* for it can be proved in geometry that of any point within the area of a circle, the centre is the nearest to every point in the circumference. In practice, however, circumstances greatly modify this theoretical principle. For example, if an abundant supply of water can be easily obtained for the moving power of the thrashing machine, the steading may be placed, for the sake of economizing horse labour, in a more remote

and hollow spot than it should be in other circumstances. For the purpose of conveying the manure down hill to most of the fields some think the highest ground near the centre of the farm is the best site for the steading. Others prefer the *lowest* point near the centre, because the grain and green crops being then carried down hill to the steading, the labour would be less than carrying them up hill, and they are heavier than the grain crops and manure. In selecting either of these sites it seems to be forgotten that loads have to be carried both *to* and *from* the steading, so that either position will answer, provided there be no steep ascent to or from the steading. The lower situation is, however, more consonant with experience and reason than the higher, though level grounds afford the easiest transit to wheeled carriages." So much for what an eminent agricultural authority states on the important point of position of the steading. It may be well, however, to give here an epitome of what Mr. Newlands, in his article on "Farm Buildings," in the Cyclopædia of Agriculture, has on the matter, more especially as he adverts to points, as quality of soil, &c., to which Mr. Stephens makes no allusion. Mr. Newlands sets out with saying that the conditions of a farm steading may be classed under two heads, the permanent and the improvable. Climate he places under the permanent division. As this cannot well be improved, he therefore holds that the steading should never be placed in a moist or humid climate; a cold climate may be improved, he says, by planting, a "weeping climate" never. With reference to aspect, this ought to be decided in some measure by the point from which storms most rarely come. Generally speaking, the south-east aspect is the best in this country. The nature of the soil and subsoil is a point of no small importance. Clay is the worst, gravel the best to build upon. The supply of good water is of imperative importance, and to secure this it will frequently be requisite to sacrifice what might otherwise be considered a central position for the steading. As to the vexed question whether the steading should be placed on the highest or lowest point of the farm, Mr. Newlands is of opinion that it may "be held a rule of very general application that the homestead be placed on a gently sloping surface, rather lower than the average elevation of the farm. If, where water power exists, such a situation can be found, it is well to take advantage of it. But if, to secure such power, it is necessary to place the buildings where light, warmth, ventilation and drainage, cannot be obtained in perfection, then the water power ought to be sacrificed to these more important benefits. The position of the homestead is often determined by the existing roads and divisions of the farm, irrespective of the eligibility of the situation itself. This is an absurd practice, and cannot be too strongly reprehended."

5. Having considered the question of site, or position, we now come to the important part of the arrangement of the apartments of the building itself. It is unnecessary to say that it is on this arrangement of the buildings that their perfection, or approach to it, depends. It is a subject which has received the attention of the best of our agricultural authorities. The opinion of a few of these we now propose to give.

6. A few years ago the Council of the Royal Agricultural Society of England gave a prize for the best plan of Farm Steading, this being awarded to Sir John Tancred, Bart. In the number of the journal of the Society in which this plan is given, are some remarks by the Prize-Committee as to the principles which should guide those engaged in the planning of farm-buildings. These we now append:—

7. "One of the first points which will strike every one conversant with farm-buildings is, that in all the plans now published the old method of building round a rectangular area, and using the enclosure as a straw-yard, has been either given up or very much modified. The cause of this change is obvious. So long as farm horses were fed on unground corn and uncut hay or straw, it was only necessary that the stable should be conveniently placed with respect to the barn and the hay-stack; and when the cattle were wintered chiefly on straw—which was supplied to them direct from the barn-door—the old-fashioned square yard, surrounded by buildings, was probably the best that could have been adopted, inasmuch as it took up the least room, and was the cheapest mode of supplying shelter for the cattle.

8. "By degrees, however, it was discovered that if the horse corn were ground, and the fodder cut into chaff, not only was the food consumed with less waste, and more perfectly digested, but the labour of mastication was materially reduced, and the animal power economized and reserved for more profitable employment.

9. "The same principle holds good in the feeding of cattle, and of late it has been carried a step farther, and heat has been applied either to steam or scald the chaff with linseed gruel and meal, with the view of rendering the nourishing ingredients of the food more perfectly digestible, and of supplying artificially the heat which must otherwise be produced by a waste of the animal tissue.

10. "It is unnecessary to pursue the subject further, as it would be easy to show that in other branches of farm management the same principle is being carried out, and it may be stated generally, that it is found profitable to call in the aid of machinery, and to make the business of a farm approximate more closely to that of a manufactory.

11. "The necessary consequence of this change of system is a great increase of intercommunication between the different buildings of a farm. The straw which formerly went from the flail to the rack now goes in the first instance to the chaff-cutter, from thence to the boiling-house, and lastly to the stable, or cattle-shed, so that it is becoming more and more important that the straw-barn, the chaff-house, the cooking apparatus, and the live stock, should be as near one another as possible. Hence one of the indispensable requisites of a modern farm-yard is great facility of communication, especially between the buildings just named; and a single glance at the prize, or the commended plan, will show how much easier of access buildings are when placed in a paved or macadamized yard, than when the whole interior is occupied as a straw-yard. Any inhabitant of a town who had frequent intercourse with his opposite neighbours would know how to appreciate the difference between crossing a square and crossing a street, and in the case of a farm-yard there is the additional inconvenience of crossing the midden.

12. "Another point of importance is that the straw-barn should be as central as possible. The great inconvenience of moving straw to any distance, especially on a windy day, is so well known that it is quite unnecessary to offer any proof under this head. In all the plans now published the barn is tolerably well placed; the Prize Plan (see par. 24, fig. 1), however, and Mr. Hudson's (see par. 26, fig. 2), carry it a step further than the rest, and place the straw-barn—where assuredly it ought to be—in the very centre of all the stock.

13. "These main points having been provided for, the next feature of importance is that the buildings should be conveniently grouped together. An excellent specimen of convenient arrangement is seen in the prize plan, where the stable will be found surrounded by everything pertaining to the food or the work of the horses. At one end is the straw-barn and the steaming-house; at one side is the blacksmith's shop, while the sheds for large and small implements are immediately adjoining, so that whatever the work may be for which the horse is taken out of the stable, the cart, the plough, or the drill, is on the spot, and if an implement requires repair, both carpenter and smith are close at hand. It would probably be better that the small implement-shed should be made to change places with the smith's and carpenter's shops, so that the forges should be farther from the stack-yard; with this trifling alteration the arrangement of this yard is very complete; and the office for the farmer at the entrance-gate ought not to be passed over in silence, as it would obviate the necessity of many an adjournment to the house, and many a handing down and dusting of 'master's desk,' besides saving much valuable time that is lost in hunting for bills and other papers that are seldom forthcoming when wanted."

14. The prize *plan* here alluded to will be illustrated in the course of this Essay; meanwhile we proceed to give the opinions of other authorities. Those now following are from Mr. J. Ewart, the Agricultural Engineer, who has issued some excellent plans for farmeries, and from Mr. Andrews, the author of "Modern Husbandry;"—

"It is of the greatest importance in designing a farmery that the principal building should be so arranged that in the event of any future alteration in the size or mode of cultivation of the farm, an adaptation of any of the buildings to suit change of circumstances may be effected without derangement of the plan or impairing the usefulness of any other building as to its relative position if its purpose be not changed by the alteration. Oversight of such provision in planning a set of farm offices has frequently occasioned much future expense, and is very often the principal cause of the inconvenience of arrangement so commonly to be observed where alterations (especially extensions) of farm buildings have taken place.

15. "To prescribe a rule by which the arrangement of farm-buildings will be applicable to all cases with equal advantage is impossible, as peculiarity of the form of the surface of the site, opportunity of applying a stream of water as the motive power of machinery, and many other incidents, may render a special modification of a plan necessary to obtain complete convenience, which, under circumstances not requiring special provision, might be in every respect the very best that could be devised. As a general rule, subject however to exceptions from a variety of circumstances for good arrangements of farm-buildings, the barn and its appendent conveniences should occupy and form a side of a rectangular court; the stables, sheds, and cattle lairs, form the adjacent sides; whilst the dwelling-house, dairy, and domestic offices, should occupy the fourth, or opposite side of the rectangle. The interior of the rectangle should have an uninterrupted exposure to the sun's rays at noon."—('A Treatise on Agricultural Buildings,' p. 6: Longmans & Co.)

16. "The following are remarks of Mr. Andrews, in his work 'Modern Husbandry:'—"To arrange the various offices in the best manner in which the business carried on will be conducted in reference to each other, so that when the plan is completed, all those apartments having anything in common with each other shall lie together, the parties employed in them not having to waste their time in passing to and from different offices distantly situated, nor heavy weights to be carried an inch farther than there is positive necessity for. . . . .

17. "The leading principle to be carried out is, to make the passage of the straw (which is the bulky article) progressive from its arrival at the barn until it reaches the manure depôt, never returning or being unnecessarily carried about, which is too often the case. The straw-barn, therefore, should be placed close to the rick-yard, so that, after it has been thrashed it may proceed to a receptacle from which it may be conveniently supplied to all the different courts, sheds, and hemmels, that contain the stock; and the manure depots must be placed so that they may receive it when it is removed from these offices as easily as it was previously supplied to them.

18. "The thrashing-barn should be placed between the rick-yard, or corn-barn, and the apartment for the unthrashed straw, into which the thrashing machine should deliver it at once from the shakers.

19. "The granary should be so situated that the corn may be removed from the thrashing-barn with despatch and ease, and without subjecting the grain to the pilfering of dishonest people, or to any injury from inclement weather. The buildings that contain the stock must be so arranged that the food and litter may be conveyed to them without unnecessary carriage.

20. "The yards and stock-courts must be roomy and enclosed, well sheltered from the north and east, and be perfectly free from draughts. The other offices should be placed as near as possible to that department with which they are more particularly connected; while the whole should form large simple masses, enclosing areas of rectangular shapes. As few breaks, angles, and projections, as possible should exist, as they increase the cost of construction, and waste the space which the steading should occupy."—'Modern Husbandry,' p. 63.

21. The last authority we now quote is Mr. Newland, to whom we have already alluded as an authority on the subject:—

"The leading object to be arrived at in the arrangement of the plan is economy of time and labour in the performance of the work to be carried on. In following this object there are two important principles which should guide the designer; the first, that there should be an immediate connection between those buildings, or apartments, whose usefulness depends upon each other; the second, that houses used for analogous purposes should as much as possible be classified and arranged together. In carrying out the first of these we shall find that the position of the barn governs that of the other buildings or apartments; for the straw-barn being the great store-house of forage and litter, from which the stables, feeding-houses, sheds, and yards, receive their supply, it is necessary that these be situated as near to it as possible, and those the nearest to which the greatest and most frequent supplies have to be conveyed. Again, the straw-barn is an appendage to the barn where the corn is thrashed; there is a necessary connection here also. To the corn-barn must be attached the building which contains the motive power to drive its machinery; and it is a convenient arrangement to have the granary in immediate connection with the corn and dressing-barn. Further, the house where food is consumed should be in connection with, or at least not far removed from, the house in which it is prepared, and this, again, should be contiguous to the places where the food is stored. Lastly, that the cleaning out of the houses may not consume unnecessary time, the place where the manure is deposited should be near to them, and of ready access.

22. "It should always be borne in mind that it is more important to save time in comparatively insignificant operations of frequent occurrence than in larger matters, which are not often repeated. Thus, it is better to have the house where food is prepared, and whence small quantities are taken several times each day, close to the place where food is consumed, than to have it near the store-house, from which the supply may require to be carried only once.

23. "The second principle of arrangement, although subordinate, is yet of great importance—it is to classify and arrange the buildings or apartments used for like purposes. Attention to this greatly facilitates the labour of the homestead. Thus, the houses and yards for particular descriptions of stock should be placed together; the working cattle should be kept by themselves; the cows of the domestic dairy should be kept apart from the feeding stock; the pigs and the poultry should each have their proper locality. It is of great assistance to this classified arrangement to have a working-court, or yard, round which are assembled in their proper places the apartments for storing and preparing food; the sheds where the wheel carriages are kept; those in which the blacksmith and carpenter work; and the others used occasionally for various purposes. And in addition to this, it is important to place the highest buildings so as to afford shelter from the prevailing winds, and yet not to intercept the rays of the sun from the other buildings and the yards. In many situations it is desirable that the whole of the outhouses should be so arranged as to have one common entrance, which can be closed for security every night."—"Cyclopædia of Agriculture," vol. i. p. 789. Mr. Newland enters minutely into an explanation of the principles which, in his opinion, should decide the *form* which the buildings should assume when arranged together. For his remarks on this subject we beg to refer the reader to the above article.

24. Such may be taken as a *resumé* of the opinions of the leading agricultural authorities on the points to be considered in the building and planning of Farm Buildings. The whole subject will, however, be found gone into with a completeness of description and a richness of illustration seldom attempted in agricultural literature, in the "Book of Farm Buildings," by Henry Stephens and Robert Scott Burn (Blackwood & Sons, Edinburgh), to which we may refer the reader desirous of fully investigating the subject in its entirety. Meanwhile, we proceed to present our readers with a few plans, from which they will be able to cull some information of value. The first to which we direct their attention is the Prize Plan of the Royal Agricultural Society of England, to which we have already alluded (par. 6). In the diagram in fig. 1 *a* shows the position of engine and boiler-house; *b* the barn—this containing the separating-machine, the corn elevator, the winnowing-machine, and the corn-bin; *c* the steaming-room, containing the boiler and steam-chest for cooking the food; *c′* the root-store—in this apartment are kept the root-cutters. The cattle-boxes are arranged in the apartments marked *d d*. In the range to the right of the central part are the following apartments:—a shed *e e* for various purposes; *f f* shed for lambing ewes; *g* boxes for milk cows; gig-house, harness-room, and stable, are arranged in the space *h*; a turnip-store is at *i*; and the dairy at *j*. In the central space are placed the covered manure, or dung-heap *k*; the pig-boxes *l*, with breeding-styes *m* and covered court *n*. In the range to the left of the central part are the following apartments:—*o o* shed for calves and young stock; *p* a bull, or tool-house; *q*

Fig. 1.

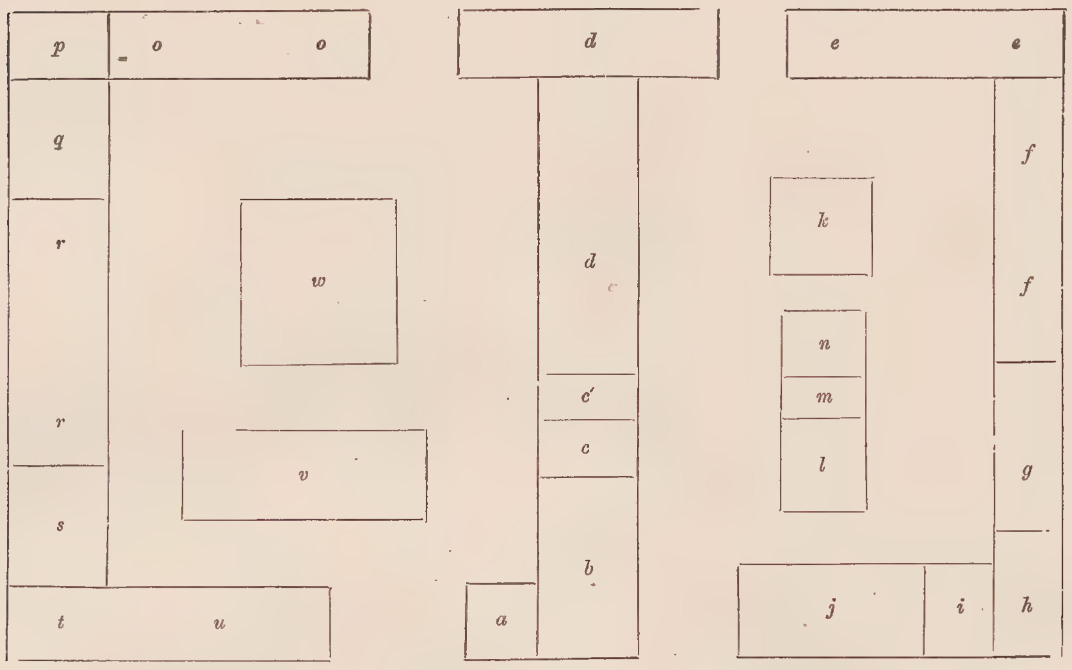


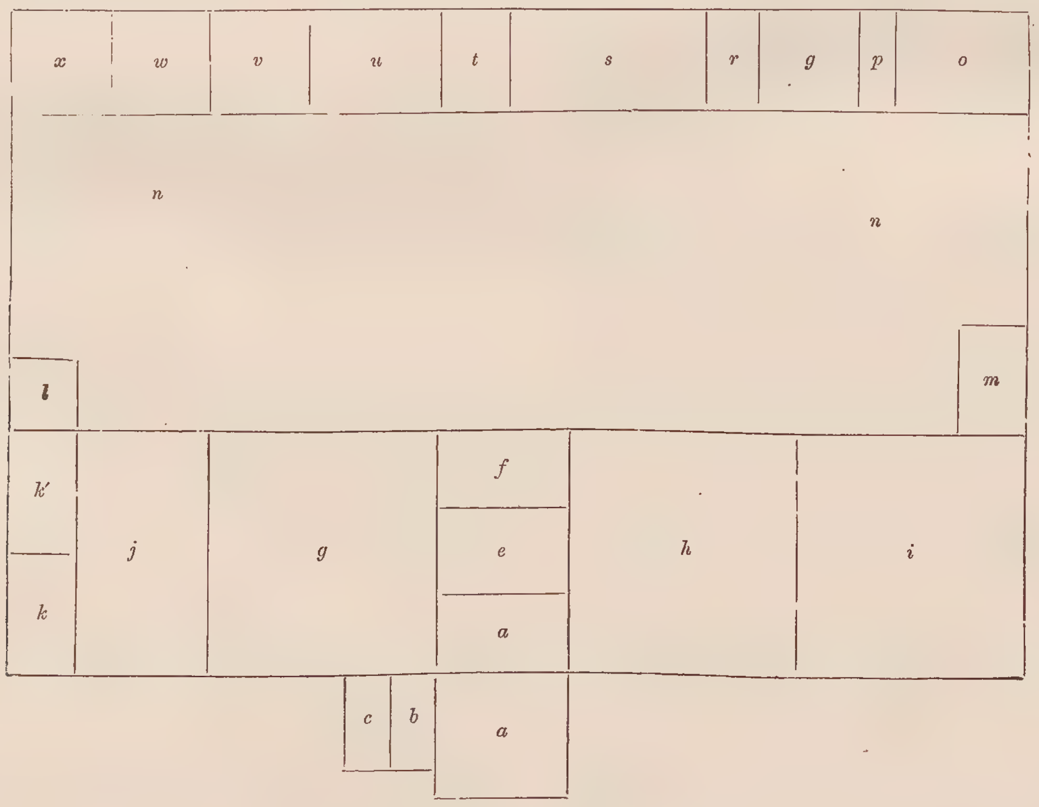
Diagram showing arrangement of the Prize Plan of Farm Steading of the Royal Agricultural Society of England.

shed for mixing manure and ashes; *r r* large implement shed; *s* small ditto; *t* carpenter's shop; *u* smith's ditto. In the central space *v* is the part occupied by the horse-boxes; *w* sheep-ties, or sheds for fattening sheep. All these apartments are on the ground floor; the second story is above the apartments *a*, *b*, *c*, and *d*, *j*, *i*, and *h*. In the apartment above *a* is the granary and steam-drying room; above *b*, *c*, and *d*, is the room which contains the millstones, the thrashing-machine, linseed-crusher, oil-cake breaker, straw-cutter, corn-loft for horses, and straw-barn. In the apartments above *j* is a cheese-room; above *i* a poultry-house; above *h* a hay-loft.

25. The following is a *resumé* of Sir John Tancred's statement of the principles on which he has arranged the buildings now described:—"The stack, or rick, is placed to the north, towards *a b*, fig. 1, from whence the grain is delivered to the thrashing-machine in the barn, the grain being delivered from thence into sacks below, ready for the market, and the straw carried forward into the upper story. The grain-crusher, oil-cake breaker, &c., placed on the second floor, deliver the work into appropriate receptacles on the ground floor. At this central portion of the building is placed what may be called the *kitchen*, in which the various food of the stock is prepared, and from which it is delivered to the several apartments inhabited by the stock, and all of which converge to this point. The manure made in these apartments is led off through the further extremity of the yard, either to the land or to the manure depôt. By this arrangement the chief part of the steading is kept clean, no litter, &c., being visible except at the further extremity, where young stock, pigs, &c., are kept; and even this may be avoided by feeding these in stalls or sheds. On entering the steading the power is met with on the left hand—the engine, horses, the implements and machines with which these are connected, and the workshop in which they are repaired; in the central parts, and to the right, are the grain, the fatting beasts, and the dairy. Beyond are the open sheds for the young animals, the whole being protected from the northerly directions by the high buildings containing the granary, &c."

26. In the same Report in which the prize plan, above described, was given, other plans were illustrated and commended. One or two of these we now explain by the help of the type diagrams. Fig. 2 is the plan proposed by Mr. Hudson of Castle Acre (see par. 12). *a* is the barn; *b* the engine; *c* the boiler-house; *e* and *f* the hay and straw-houses; *g* and *h* the cattle-courts; *i* the young cattle-court; the yard for milk cows; *k* the cow-house; *k′* the calf-house; *l* the piggery. The carpenter's shop is at *m*. The yard *n n* is enclosed by walls, in which are entrance-gates; in the lower side of the

Fig. 2.

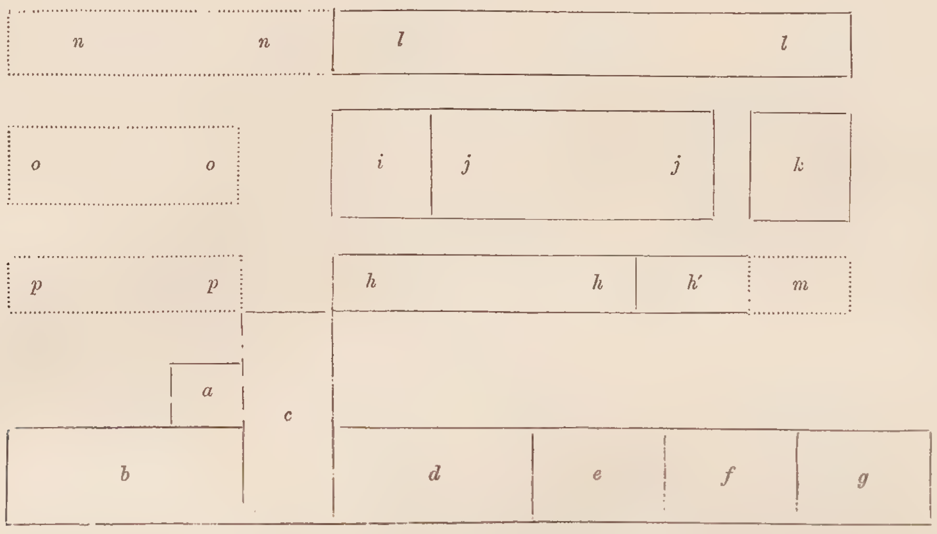


Plan of Farm Steading in Report of Royal Society.

yard is a range of apartments, of which the following is a description: — *o* cart-house; *p* harness-room; *q* cart-horse stable; *s* ditto; a corn-room *r* is placed between these apartments; *t* a harness-room; *u* the riding-horse stable; *v* the gig-house; *w* the wheat-house; *x* the poultry-house.

27. In fig. 3 we give a sketch plan of the farm steading proposed by Mr. John Ewart, Agricultural Engineer, of Newcastle-upon-Tyne. The engine-room and boiler-house is at *a*; *b* the barn of two stories; *c* the straw-barn; *d* the work-horse stable; *e* loose boxes; *f* depôt for manure; *g* the implement shed; *h h* a single range of cattle-boxes; *i* a turnip-cooking house; *j j* a double range of cattle-boxes; *k* the milk-cow house; *h′* calf-house; *l* single range of cattle boxes. If additional accommodation is required in this steading the calf-house may be extended, as shown by the dotted lines at *m*, giving a range for cattle-boxes; the range of cattle-boxes *l l* may be extended as at *n n*; the new parts, *o o* and *p p*, may be put as shown.

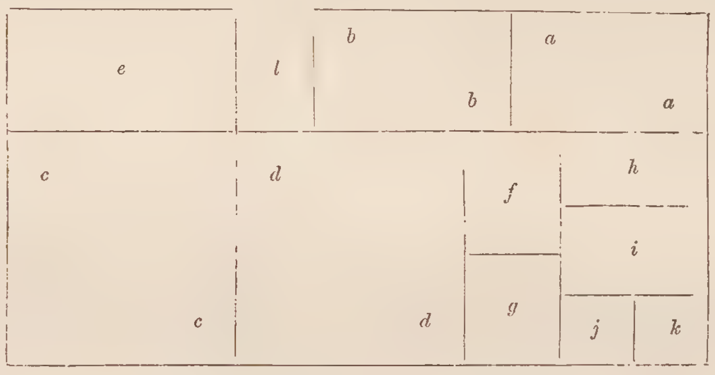
Fig. 3.



Plan of Farm Steading in Report of Royal Agricultural Society.

28. In fig. 4 we give a sketch-plan of the steading designed by Mr. James Cowie, Kincardineshire, and for which he received the prize of the Highland and Agricultural Society of Scotland.

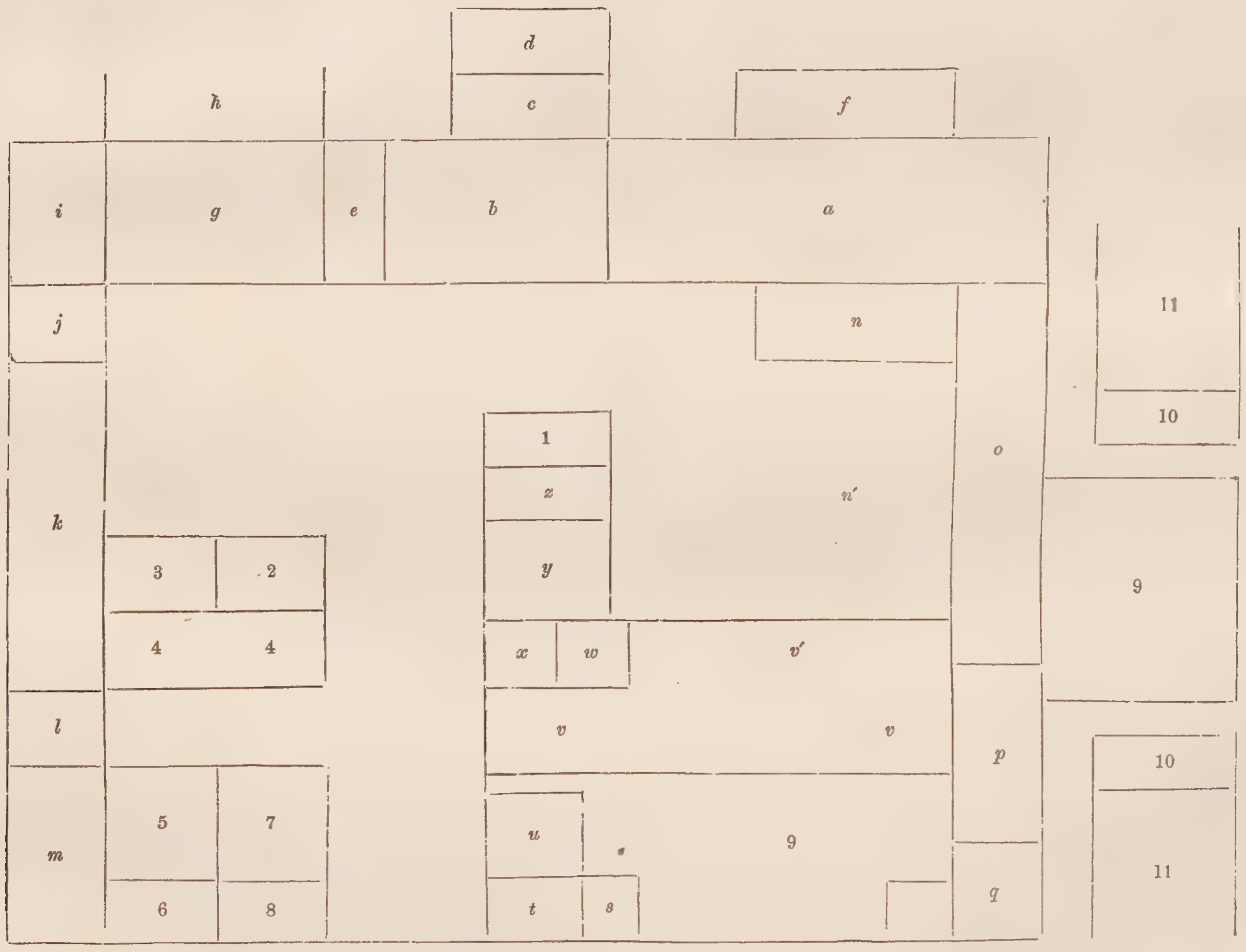
Fig. 4.



Highland Society's Prize Plan of Steading.

The corn-barn is at *a a*; the straw-barn at *b b*; the cattle-shed at *c c*; the cow-byre at *d d*; *e* the cart-horse stable; *f* cow-byre; *g* turnip-shed; *h* tool-house; *i* stable; *j* poultry-house; *k* cooking-house; *l* cart-shed.

Fig. 5.



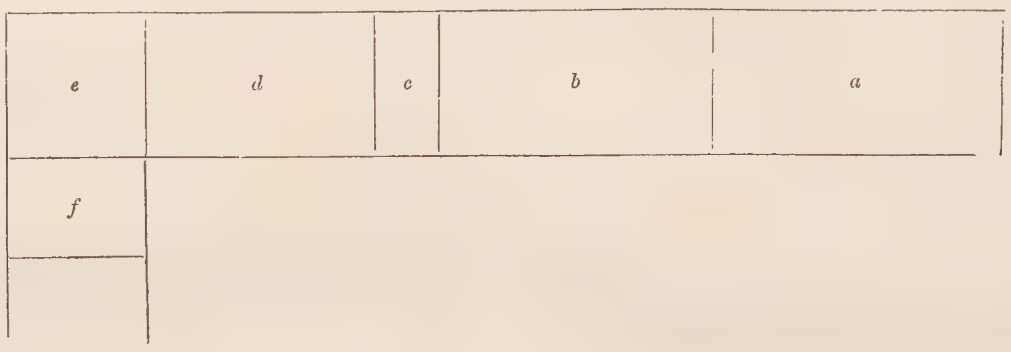
Highland Society's Prize Plan of Farm Steading.

29. In fig. 5 we give a sketch of the arrangements of the steading designed by Robert Bell, Esq., architect, of Edinburgh, and to which the gold medal prize was awarded by the Highland and Agricultural Society of England. It is designed for a farm of 500 acres, under the mixed husbandry system, with a six course rotation, where the green crops and

straw are consumed on the farm. In fig. 5 *a* is the straw-barn, 70 feet long by 17 feet broad; *b* the corn-barn, 46 feet by 19 feet; *c* the engine-house, 19 feet by 9 feet; *d* the boiler-house, 19 feet by 7 feet; *e* a corn-bruising house, 17 feet by 10 feet; *f* is a house for cut straw, 54 feet by 10 feet—it enters from the straw-barn; *g* the cart-shed, 41 feet 6 inches by 17 feet; *h* the implement-shed, 38 feet 6 inches by 10 feet. The hay-house *i* is 18 feet 6 inches by 17 feet; *j* the harness-house, 10 feet 6 inches by 9 feet 6 inches; *k* stable for 13 horses, 78 feet by 18 feet; *l* a loose box, 10 feet by 18 feet; *m* potato-house, 48 feet by 18 feet; *n* a cattle shed, 38 feet by 12 feet; entering from the cattle-yard *n′*, 70 feet 2 inches by 44 feet 1 inch; *o* cow-byre for 20 cattle, 70 feet by 17 feet; *p* ditto for 14 cattle, 49 feet by 17 feet; *q* cow-byre for 6 cows, 21 feet by 17 feet; *r* a calf-house, 12 feet by 11 feet; *s* a tool-house, 12 feet by 11 feet; *t* a gig-house, 16 feet by 12 feet; *u* a shed for cattle, 39 feet by 16 feet; 9 the cattle-court, 70 feet 2 inches by 59 feet 5 inches; *v v v′* box feeding-byre, in two rows, with railway between—there are five boxes on the side *v′*, seven on the side *v v*; *w* is a turnip-house, 10 feet 6 inches by 8 feet 6 inches; *x* an oil-cake house, 11 feet 6 inches by 10 feet 6 inches; *y* is a boiling-house, 16 feet square; *z* poultry-house, 16 feet by 8 feet 6 inches; 1 is the infirmary, 16 feet by 9 feet 6 inches; 2 is the riding-horse stable, 18 feet by 17 feet; 3 the cart-shed, 20 feet by 17 feet; 4 4 a range of pig-styes; 5 a court for young horses, 25 feet by 19 feet; 6 its shelter-shed, 19 feet by 13 feet; 7 a young cattle-court, 18 feet 10 inches by 25 feet; 8 its shelter-shed, 19 feet by 13 feet; 9 is a turnip-house, 36 feet by 28 feet 6 inches; 10, 10 urine tanks, 25 feet by 6 feet; 11, dung-pits, 43 feet by 25 feet.

30. In fig. 6 we give the plan of upper, or granary floor:—

Fig. 6.

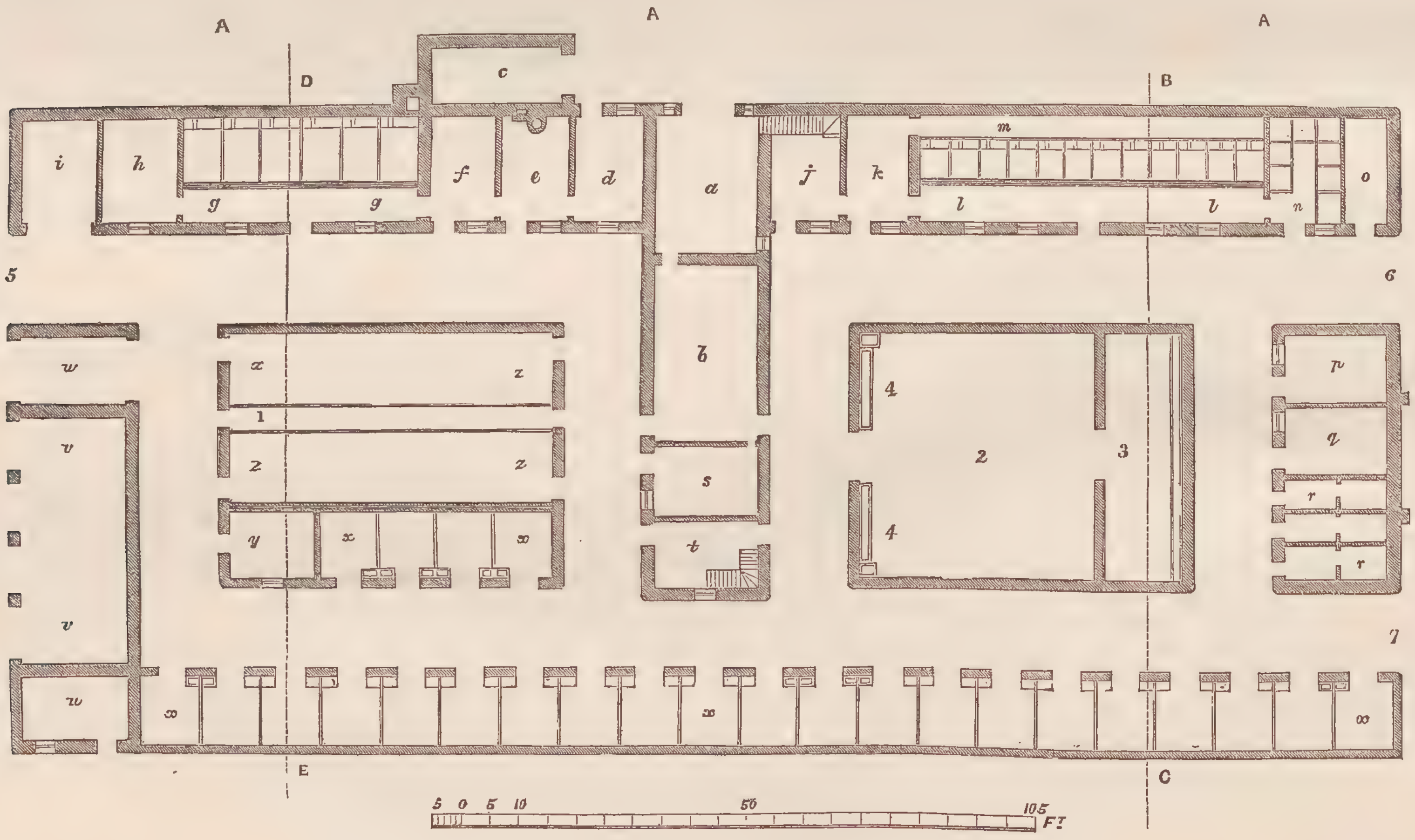


Upper Floor Plan of Fig. 5.

a is the straw-cutter loft, 41 feet by 17 feet; *b* the corn-barn loft, 46 feet by 19 feet; *c* bruising-loft, 10 feet by 19 feet; *d* granary, 41 feet 6 inches by 17 feet; *e* horse corn-loft, 18 feet 6 inches by 17 feet; *f* beds for farm-servants.

31. In Plate XV., figs. 1 to 5, we give a set of plans for a farm steading on the mixed husbandry system, adapted for a farm of 100 or 150 acres. These consist of a ground plan, front elevation—section in line A B, end elevation at C, and back elevation. In fig. 7 we give the ground plan of a farm steading for 200 or 250 acres on the mixed husbandry system.

Fig. 7.

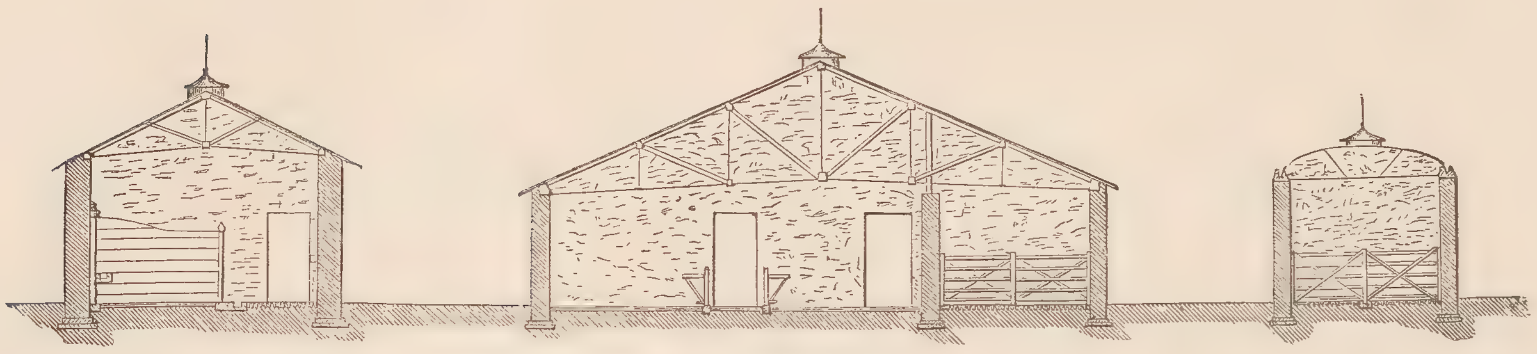


Ground Plan of Farm Steading for Mixed Husbandry for 200 or 250 acres.

In this *a* is the corn-barn; *b* the straw-barn; *c* the boiler-house; *d* the steam-engine house; *e* the boiling-house; *f* hay-house; *g g* the work-horse stable; *h* a loose box; *i* the gig-house; *j* the root-cutting room; *k* the mash or boiling-house; *l l* cow-house, or byre, with feeding-passage *m*; *n* calf-house; *o* the poultry-house; *p* a bull-house; *q* turnip-store; *r r* pig-styes; *s* the infirmary; *t* turnip-store, with a store-room for wool, &c., over; *u* the work-shop; *v v* the cart-shed and implement-shed; *w* dung-pit; *x x x* and *x x* two ranges of cattle-boxes; *y* an oil-cake store; *z z* sheep-sheds, with feeding-passage 1 1; 2 a cattle-court; 3 shelter-shed; 4 4 turnip-troughs. The rick, or stack-yard, is at A A A, the north side of the building. The whole buildings are enclosed, gates being put at the points 5, 6, and 7. In fig. 8 we give a section through the line C D in fig. 7; and in fig. 9 a section through the line D E. In Plate XV. we give the elevations of this steading—a front elevation in fig. 6, an end elevation at the end *w*, fig. 7, and end elevation at the end *v v*, fig. 7. The scale of these elevations is the same as in figs. 8 and 9.

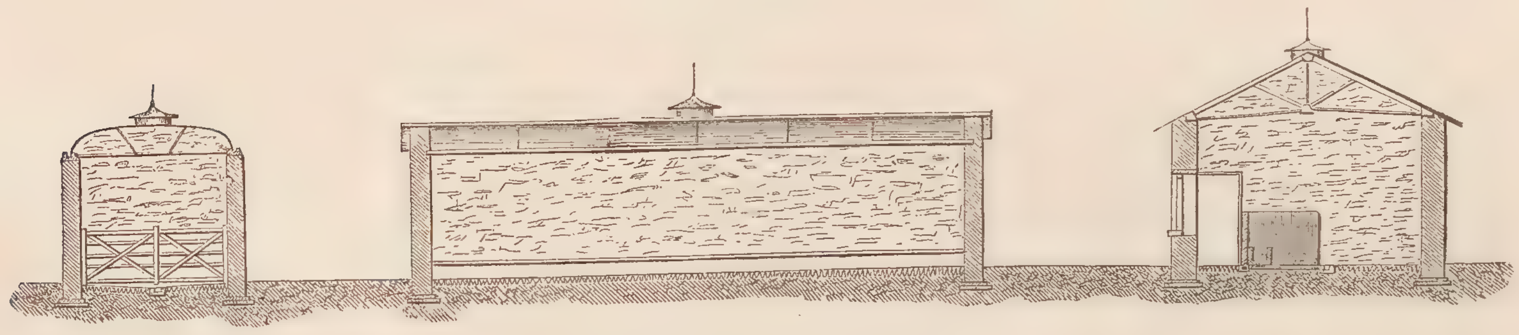
32. As it is of importance to understand the principles of

Fig. 8.



Section through line D E in fig. 7—Scale double that in fig. 7.

Fig. 9.



Section in line B C, fig. 7—Scale double that in fig. 7.

arrangement of farm-buildings, it will be useful, before presenting the plans which we have yet to give, to return again to the Report of the Royal Agricultural Society before alluded to, and to note what the judges say with reference to the prize plan described and illustrated in fig. 1. In awarding the prize to this plan they were guided by certain considerations which seemed to them of primary importance. In the first place, it was one object with them that the prize should be given to a plan which should be as *generally useful* as possible. They were well aware, however, that no one plan could possibly meet the wants of the great variety of soils, climates, and modes of farming which exist throughout the kingdom; they therefore sought to find a plan which, not only good in itself, was capable of extensive alteration without sacrificing its general plan of arrangement, and which also contained the greatest number of useful suggestions admitting of being separately introduced by those desirous of adding to existing buildings, or by those who did not care to use the prize plan as a whole. They also bore in mind that it was essential in a prize plan that it embodied all the recent improvements in farming, as steam-thrashing, stall-feeding, and other modern practices. In connection with the plan in fig. 1, and the above remarks, it will be suggestive if the reader will now peruse the following review of the prize plan by the judges, showing to what extent it possesses a capability of adaptation to different systems of farming.

33. "Commencing with the barn, it has been already shown (par. 12) that the straw-barn is in its right place; if a corn-barn were required the building would have to be extended into the stack-yard to the desired length; if thrashing by horse-power were preferred to thrashing by steam, the horse-walk would occupy the space now appropriated to boiler and engine-house. On entering the yard the same facility for re-arrangement will be found. Beyond the stable a considerable building is provided for tying up sheep. This would not be generally required; and if it were dispensed with, and the yard for young stock enlarged by moving the partition-wall somewhat nearer the stable, provision would be made for the accommodation of the additional store-cattle, which might be kept by those who did not consume their turnips with sheep.

34. "If the occupier preferred a stable of the ordinary kind in lieu of boxes, no further change would be required than to place the stable lengthwise instead of across the yard, so that one end would abut upon the yard for young stock, and have a door opening into it for the litter to be carried out in the ordinary way. Again, if the buildings were intended for a farm of large size, the accommodation for feeding cattle might be readily increased by extending the double range of boxes right and left at the end of the present row, and an additional turnip-house about the centre of the new range would make that a convenient arrangement; perhaps even a turnip-house so placed would be a useful addition to the present plan, as the turnips would be in a good position both for the fat and store stock, and the space now occupied by the root-house might be advantageously disposed of as a depôt for straw on the ground floor, which few farmers would like to be without. If it were thought desirable not to change the place of the root-store, the straw-house might still be provided by giving up the first two boxes for that purpose. Some difference of opinion yet exists as to the comparative advantages of feeding cattle in stalls or boxes; if the former be preferred, and the ground now occupied by boxes were fitted up with stalls, nearly three times as many cattle could be accommodated; the manure would then be daily carried in a truck on the tramway, or wheeled along an ordinary causeway, either to be at once made into compost by admixture with soil, ashes, &c. (a practice which cannot be too highly commended), or to be thrown out by a side door into the adjoining yard. Should a plan be required for a mixed arable and dairy farm, the present cattle-boxes would make an admirable cow-house, with stalls for fifty cows; and as dairy-farms are usually small, the second yard—now chiefly devoted to cows and pigs—might probably be dispensed with altogether, with the exception of the dairy and pig-sties, which would form proper appendages to the yard of the farm-house, the site of which is indicated in the plan.

35. "A sample has now been given of the almost unlimited capability of alteration possessed by the prize plan without destroying its leading features; the same may, to a great extent, be said of the commended plan (Mr. Hudson's, see fig. 2 and par. 26). There are, however, some points in the latter (perhaps it should be said of all the plans) which are not approved by the judges; and as it is an invidious course to point out faults in plans which contain so much that is worthy of praise, the same end will probably be attained in a more agreeable way to all parties by stating in general terms what the judges think ought to be provided in a plan of farm-buildings, leaving the reader to make the application for himself.

36. "In general terms, then, the main objects contemplated in making farm-buildings are—1st. To make convenient arrangements for thrashing, and preparing for market the grain crops. 2d. To provide accommodation for the live stock.

37. "On the first head little need be said; the position of the straw-barn has already been spoken of, and provided that the corn-barn be conveniently arranged, and proper facilities afforded for the employment of either steam or horse-power, the designer of the plan will have done his part; the rest will depend on the judgment of the occupier in selecting his thrashing-machine and other barn implements.

38. "The accommodation for stock is a much more difficult subject, and in a brief sketch of what is required, it will be necessary to keep constantly in mind that in the housing of live stock, and the preparation

of their food, the first object should be to enable the animals to derive the greatest possible benefit from their food; and the second, to preserve the manure from deterioration or waste. The food annually consumed on every farm by the horses and other live stock would, if its money value were stated, amount to such a sum as to impress every farmer with the importance of economising its use; and the difference between the value of a substance for feeding purposes and its value when in a state in which it can only be used as manure, is so considerable that it is very bad policy to be lavish in the supply of food, because what is left or wasted makes capital manure. The value for linseed cake or manure is (so far as can be ascertained) about the same as that of rape-cake; but the former has an additional value for feeding, which makes it about 50 or 60 per cent. dearer than the latter; any linseed cake, however, which is not digested by the animal, and remains in the manure, is worth no more than an equal quantity of rape-cake, or, in other words, it has lost more than one-third of its previous value. Hence any arrangement by which one animal has more food than he can digest, and another less than his share, is on both accounts a source of loss to the owner, and if the stock is exposed to the cold in winter a further loss takes place; but if, by grinding, steaming, or other preparation of the food, and by the use of warm boxes or stalls, in which each animal receives its allotted portion, more of the food is converted into fat and flesh, and less remains in the manure, as saving is effected, not only in the more uniform thriving of the stock and the smaller portion of food which is expended in maintaining the animal heat, but also in the difference in value between a feeding and a manuring substance, the proportion between which has been pointed out in the case of linseed-cake, but which there are as yet no data for calculating in the case of corn, hay, or roots. Again, the undigested food left in the manure is subject to further depreciation before it is applied to the land. The better the manure the more liable it is to heat, and the more it has been heated the more it suffers from rain. How, then, is it to be prevented from overheating? Compression is the readiest and most efficient way of accomplishing it, and this is obtained most perfectly in boxes, in which the manure is solid enough to prevent undue fermentation, and is also protected from rain. If straw is scarce, and stalls for feeding cattle be preferred, the labour of cutting the litter and of wheeling away the soiled part daily to mix with earth, is amply repaid in the perfect preservation of the manure which is thus obtained.

39. "The advantages of feeding cattle in stalls and boxes have been so prominently put forward of late as to lead to the proposal to dispense with straw-yards altogether. This is running from one extreme to another. It has certainly been proved, both scientifically and practically, that warmth is to a certain extent a substitute for food, and during winter fattening cattle can scarcely be kept too warm consistently with good ventilation; but it would be unwise to tender young cattle, or cattle of any sort that are not making up for the butcher, and are intended for summer grazing. Young animals also require a certain amount of exercise, which is conducive to healthy growth, and probably no arrangement is superior to small, well-sheltered, open yards for young stock.

40. "In ordinary farm-yards manure is much injured by rain water, and to obviate this it is suggested that covered depôts should be provided, where it may be deposited till wanted. The objection to covered manure-pits is, the lightness of the manure, and its consequent tendency to heat itself dry, with very great loss of ammonia. It certainly may be watered from a pump or tank, but this would only increase the fermentation so long as the heap was light; and to meet this difficulty it has been suggested that it should be frequently carted over. It is certainly *possible* by carting, or some other mechanical means, to give sufficient solidity to prevent mischief; but when the trouble and inconvenience of carting over a partly decomposed heap, and also the probability of its being neglected in busy seasons, are taken into account, it will probably be found that in the majority of cases covered manure-pits would do more harm than good. Well-spouted farm-yards, in which the manure is allowed to accumulate through the winter, and trodden firm by being well stocked—heaps in the field, well covered with soil—and loose boxes for fat cattle and farm horses, will enable a farmer to keep his manure in first-rate condition; and the importance of these and other similar arrangements cannot be too often or too strongly insisted on.

41. "The foregoing remarks lead to the following conclusions:—1. That the communication between the different buildings of a farm should be by means of a paved or macadamized yard, and not across a straw-fold. 2. That provision should be made for the introduction of loose boxes or stalls for fattening cattle. 3. That small open yards, with covered sheds, should be provided for young or store cattle. 4. That covered manure-pits are not generally advisable."

42. Those of our readers desirous to see plans *specially designed* to suit the various kinds of farming, as Pastoral, Dairy, Mixed Husbandry, Carse Farming, Suburbial Farming, &c., may consult the "Book of Farm Buildings." In connection with these will be found an exposition of the principles upon which the various plans are based, and of the benefits to be derived from specially designing plans for special objects in place of adapting or modifying a plan which has been designed for a special mode of farming, or as a model plan so called.

43. It would be an easy task to multiply plans of farmeries, but space prevents us from doing this to the extent we should otherwise have wished. Nor is it altogether necessary; what we have given on the subject of arrangement will afford much that is suggestive; and the plans we are now about to give, illustrative of the Royal and other Farmeries, will, in conjunction with figs. 1 to 9, elucidate pretty fairly the arrangements of modern farm-buildings.

44. *The Royal Farmeries at Windsor, &c., &c.**—The first of the plans which we have now the pleasure to present to our readers is that of the Home Farm at Windsor. "It is here," says Mr. Morton, in his interesting "Farm Gossip," connected with the description of the Royal Farmeries in the "Agricultural Gazette," that "the dairy herd is chiefly kept, and that the principal piggeries—those of the White Windsor breed—are placed. The whole accommodation for live stock here is of the most perfect kind." Fig. 10 gives the ground plan and an elevation along the line A B.

> "The principal feature in this arrangement is the magnificent double-rowed cow-house, with its wide central gangway, lofty roof, and roomy arrangement generally. The arrangements for watering and for draining these and all other parts of this farmery are most perfect. Only the lines of drainage are represented on the plan; but there is an equally complete system of pipage for the supply of water to troughs on one level throughout the building. It is impossible in a short description to enumerate the many clever points of detail by which Mr. Turnbull, the castle architect, has, in these buildings of his designing, obviated a great many difficulties, with liabilities to nuisance. The whole of the soakage and drainage of the sheds and yards is conducted to a manure-house situated at M on the plan, whence the liquid, collected in a tank, may be either pumped into water-carts, and removed for direct application to the land, or distributed, as it more generally is, over the stall manure, which is moved at intervals and stored for protection from the weather.
>
> "It will be seen that ready access is given to all the yards and sheds for litter, chiefly fern-leaf mown from the park, and stored away for its winter purposes—and that from the centres *m* and *b* and *u*, where pig food, hay, and roots are stored, easy access is given by the gangways *e e* to all the feeding houses, stables, cribs, and boxes where the stock are kept. The reader will easily gather by an inspection of the plan how well, and with how much economy of labour, it is adapted to its purpose.
>
> "One of the chief features in these buildings evidently is the ample accommodation for pigs—*j j* on the plan. The comparatively smaller white Windsor breed—from 16 to 20 breeding sows—are kept here. The pure Berkshire—10 to 12 sows—are kept at the other farmery. In both cases there is ample demand for the young stock for breeding purposes. Mr. Tait gives the preference to the Windsor breed, both for fecundity and for precocity. As much as £700 worth of produce has been sold out of the piggeries at the Home Farm alone in a single year."

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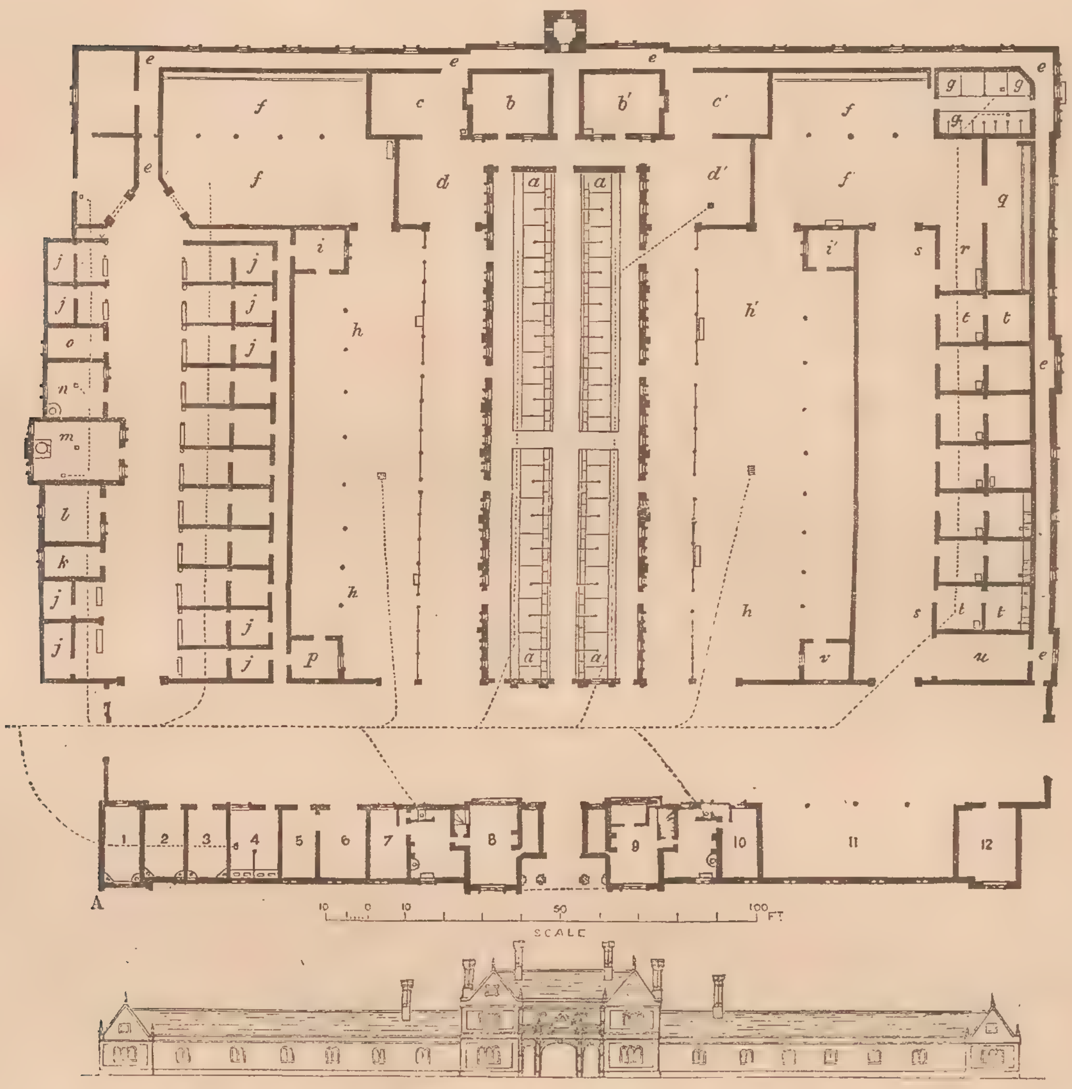
* For these plans we are indebted to the "Gardeners' Chronicle and the Agricultural Gazette." At the commencement of eighteen sixty-two Mr. J. Chalmers Morton, the well-known and able editor of this journal, commenced a series of articles descriptive of the Royal Farmeries, in which his late lamented Highness Prince Albert took so great an interest. From the value of these articles, and the drawings with which they were illustrated, we deemed them likely to be of great service to our readers. That we are here enabled to give them, is owing to the courteous promptitude with which they were placed at our disposal by the Proprietors and Editor of the journal.

Fig. 10.



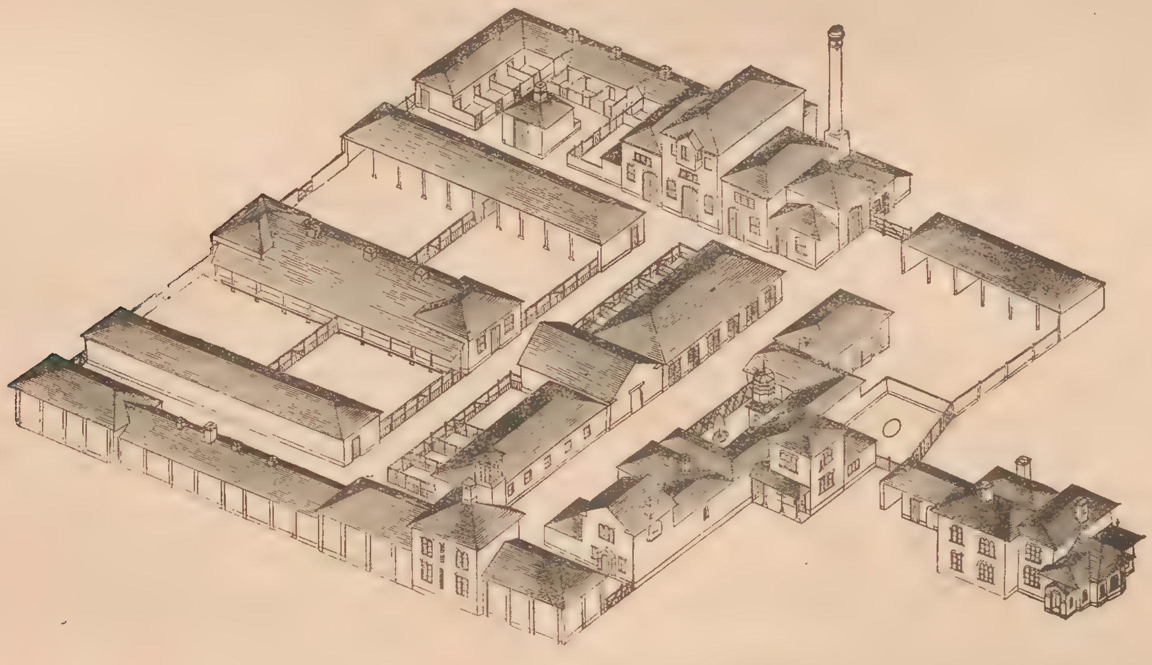
Plan and Elevation of the Home Farm, Windsor.

Nearly 200 head of stock are now kept. The following is a literal reference to the plan in fig. 10.

a a double-stalled cow-house; *b b'* hay-store and chaff-house, with granary for cake and meal above it; *c c'* straw-store; *d d'* yard and roadway; *e e* gangway; *f f'* yards and sheds for young store; *g g* calves-house and pens; *h h'* yards and sheds for cows, &c.; *i i'* calving boxes; *j j* piggeries; *k* store; *l* meal bins; *m* boiling-house for pigs; *n* slaughter-house; *o* straw-store; *p* calving-box; *q r* shed for young stock; *s* roadway and working court; *t t* "Hamels"—small yards and shed; *u* root-house; *v* calving-box; 1, 2, 3, 4, 5, 6, loose boxes and stables; 7, 8, 9, 10, houses for foremen; 11 cart-shed; 12 loose box.

45. The next of the Royal Farmeries we illustrate is that of the Shaw Farm. The buildings have been designed by Mr. Dean (author of a work on Farm Buildings and Labourers' Cottages, dedicated to His Royal Highness Prince Albert).

Fig. 11.



Isometrical Perspective View of (Royal Farm) the Shaw Farm-stead.

"In this farm the rooms erected," says Mr. Morton in continuation of the series of articles on the Royal Farmeries, "for the use of the Queen and Prince Consort are shown on the plan by the letter N, fig. 12, in the steward's house, the road to which passes the entrance to the steading. The foreman's cottage, steward's stable, gig-house, and spare boxes for horses, or other sick stock, are placed at *i* to *j*. At *k* is shown the poultry department; at *l n* blacksmith and carpenter's shop, sawpit, &c., which completes the north range.

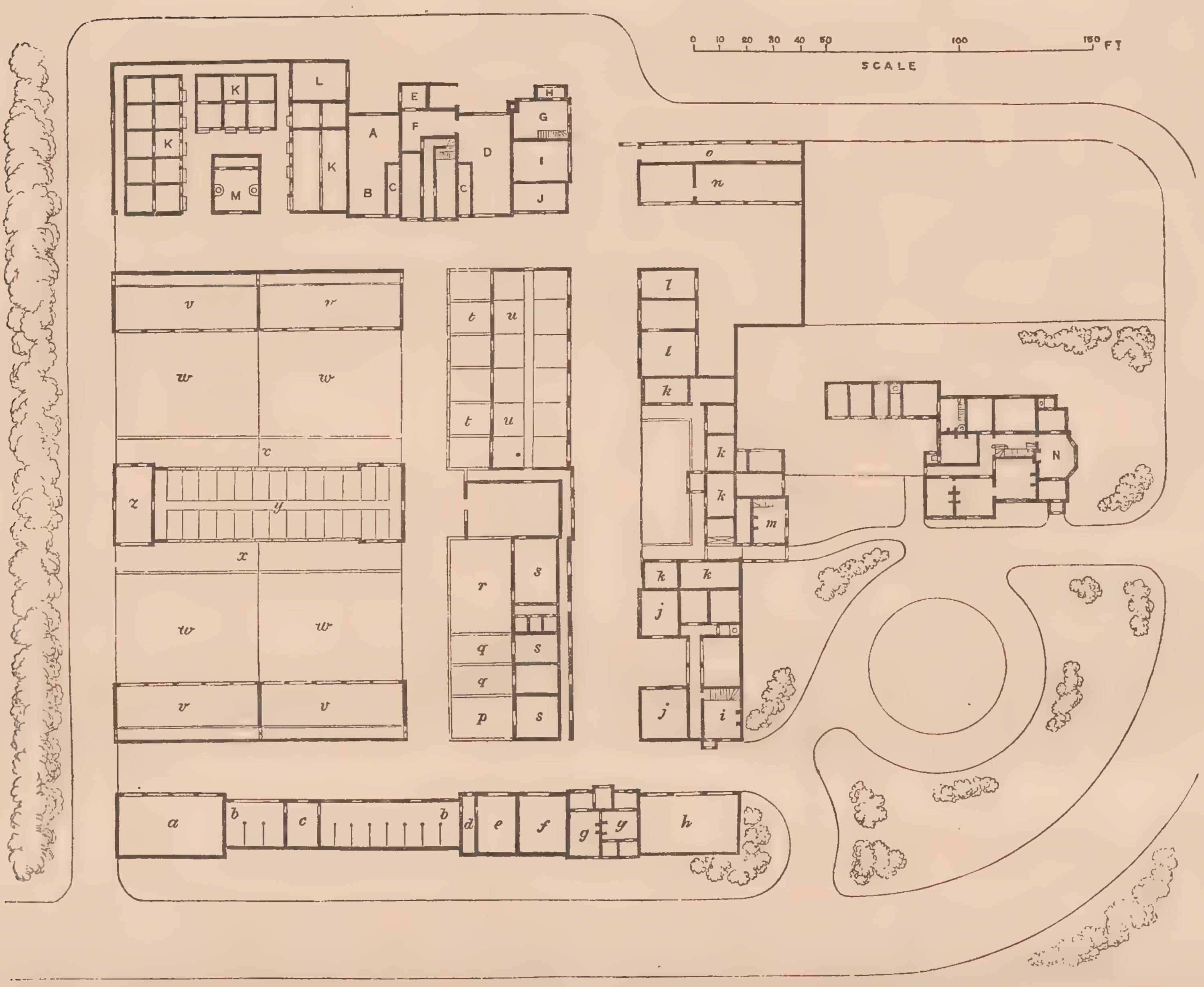
"At A to J in the west range is the thrashing, grinding, and manufacturing departments, and at K M, in the same range, the piggery department.

"The three central ranges are shown at *v, y, v*; the two outer being open stock-sheds and yards, with small lean-to sheds for rack-feeding.

"At *a* to *h* is the east range, in which are the cart and waggon sheds, cart-horse stables, the house for labourers, and school-room, clock-tower, implement sheds, &c.

OUTLINES OF AGRICULTURAL ARCHITECTURE.

Fig. 12.



Ground Plan of the Shaw Farm-stead.

"In the range from *p* to *u* are the bullock-boxes, with and without hamels or yards, provision-shed, cow-house, stallion and bull boxes, &c.

"The rooms for her Majesty are placed at the end of a fine avenue, and, together with the steward's house, form a very pleasing and picturesque object. They are of an ornamental character and considerable architectural pretensions. From these rooms her Majesty is enabled to walk in comparative privacy to the poultry department by the passage shown by *m*, and thence by means of the various passages through the whole range of buildings.

"The steward's house and offices are commodious and well arranged, and sufficiently near to without being attached to the steading.

"The poultry department is managed without interference with the farm operations, as is also the blacksmith's and carpenter's departments.

* * * * * *

"The engine, which was designed by Mr. Dean, and constructed by Messrs. Collinge & Co., works the saws, &c., in the carpenter's department as well as the machinery of the steading. Mr. Dean also arranged the extensive machinery in use, and which was supplied from Messrs. Garrett & Son's establishment.

"The barn machinery comprises, besides the thrashing-machine, oat, bean, and cake-crushing mills, a flour-mill, straw and chaff-cutters, hoisting-machinery, &c.; in short, the barn is made a complete manufactory for the conversion into food for man and beast of the produce grown upon the farm.

"In the piggery department, shown at K, the styes surround the boiling-house, at the back of which is a large tank in which the food is fermented. The central position of this building ensures economy in feeding the animals.

"The stock-yards shown at *w* are divided into four, for keeping separate distinct breeds of stock and those of different ages. The centre range comprises the sheep-shed already alluded to, as including arrangements for feeding on an open floor over a tank for the collection of their manure.

"The bullock-boxes in the range shown at letters *p u* are without hamels on the north side, while those on the south possess them. This arrangement was carried out by command, as his Royal Highness wished to ascertain which of the two plans was the best for fattening bullocks of various breeds.

"The provision shed in this range is also well placed for supplying food to animals in the various ranges of buildings.

"The accommodation for cows is small in consequence of the dairy being at Frogmore. It was therefore intended to keep but a few in this steading, and these for breeding animals intended for exhibition. The bull and stallion boxes adjoining are very commodious and well fitted up.

"The whole of the buildings are well drained and well supplied with water.

"There are various manure tanks having holes with plugs in the topstones, so that on taking out the plugs, portable pumps may be employed for pumping the liquid either into carts or on the manure in the stock-yards as may be desirable."

The following are literal references to the plan in fig. 12:—

East Range.—*a* cart and waggon sheds; *b b* cart stables; *c* harness room; *d* chaff and corn-bins; *e* hay and corn-sheds; *f* drill-shed; *g g* men's living-rooms, with sleeping-rooms over, and clock-tower; *h* implement-shed.

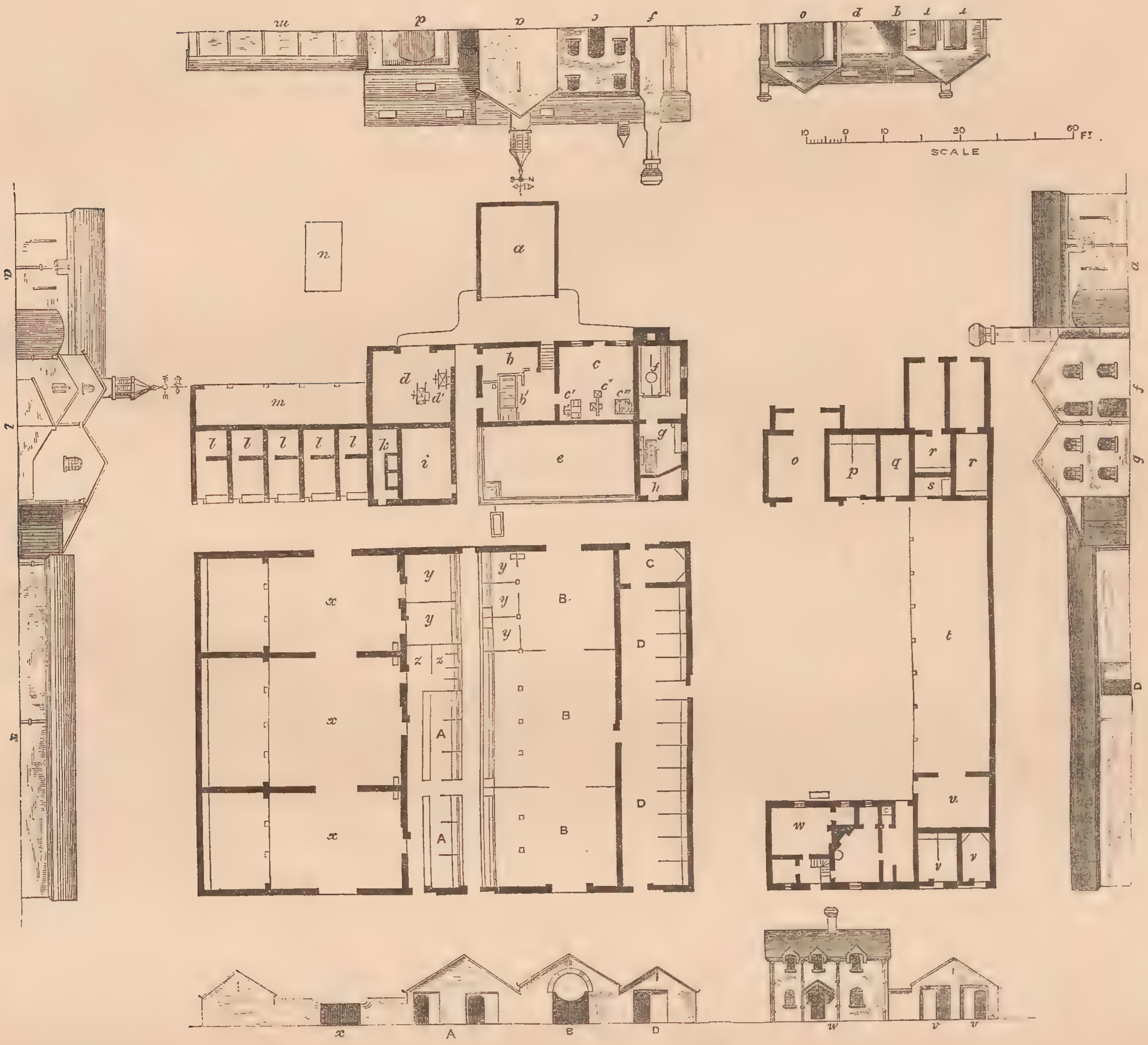
North Range.—*i* foreman's cottage; *j j* steward's stable, gig-house, and hospital for sick stock; *k k* poultry department; by *m* the entrance from her Majesty's rooms to the farm offices; *m* poultry woman's cottage; *l l n o* blacksmith's, carpenter's, and other shops, wood-yard, saw-pit, &c.

West Range.—A corn bay; B hay bay; C C cut hay and straw; by C corn-mixing rooms; F space for thrashing-machine, and stairs leading to floors above; by E shed for chaff from thrashing-machine; by F shed for corn to be thrashed; G boiler-room; H coal-shed; I artificial manure-shed; J boiling house.

Piggery Department.—M boiler-house with food-tank; K K styes and yards for breeding sows; L slaughter-house; K open sheds for store pigs.

Centre Ranges.—*v v* open stock-sheds; *w w* yards to ditto; *y* sheep-sheds for sheep; *t u* bullock boxes, with hamels, or yards; by *u* ditto without hamels; by *v s* provision-shed; by *r s* cow-house and calf-pens close by; *q p s* bull and stallion-boxes, with yards in front; feeding and inspection passages throughout.

Fig. 13.



Plan and Elevation of the Flemish Farm (Royal Farm).

46. In fig. 13 we give plans and elevations of the Flemish Farm.

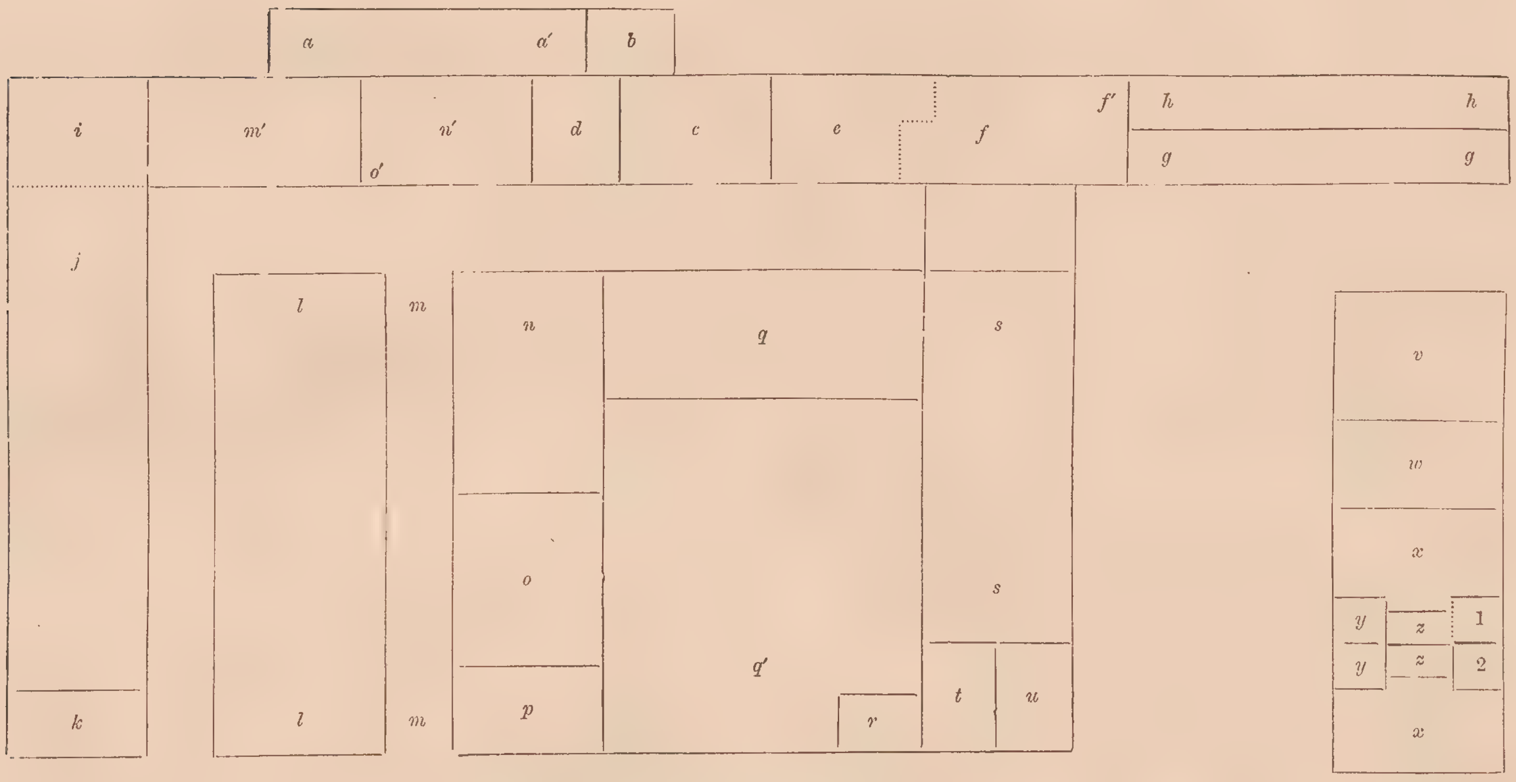
"It was designed and erected," says Mr. Morton, "by Mr. Turnbull, the Castle architect, and is a capital specimen of the style of farmery, including covered yards with stable on one side and open yard on the other, of which many examples have also been erected in different parts of the country by Mr. Wilkinson, architect, of Oxford. The connection of the various parts is most natural and obvious. The horses come out of the stable, and are at once close by the cart and implement shed. They are yoked in carts, and carry the corn from the stack through the gangway between *a* and *b*, where the sheaves are unloaded and thrashed at *b*, the straw falls away into the straw-barn at *e*, and the grain goes upwards to the granary. From *e* the straw is carried the shortest possible distance to D B Y, and *x* and *l*. If the carriage of the litter should rule the position of the several feeding places, then farmeries on this principle have been erected here and in hundreds of other places for many a long year. The soiled litter from D is thrust into the yard at B, and that from A into the yard at *x*. It thus gets trodden down into a solid material, which suffers no waste on its road to the field once more.

The following are the literal references to fig. 13.

a sheaf-barn; *b* thrashing-barn; *c* mills; *c* cake; *c″* oats and beans; *c‴* meal-mill; *d d′* turnip-cutters; *e* straw-barn; *f* boiler-house; *g* engine; *h* saddlery; *i* cut chaff; *k* pig food and cisterns; *l* piggeries; *m* shed; *n* liquid manure tank; *o* portable engine; *p* stable; *q* fowls; *r r* bulls' houses; *s* forge; *t* cart-shed; *u* implements; *v* stable; *w* loose box; *w* cottage; *x x x* cow-yards, open; *y y* feeding-boxes; *z z* calves' pens; A cow-stalls; B covered yards for young stock; C loose box; D stable; A B D are under one roof, as shown in elevation at foot of plan; the passage between barns and covered yards is also under a roof, as shown in elevation at either side of the plan.

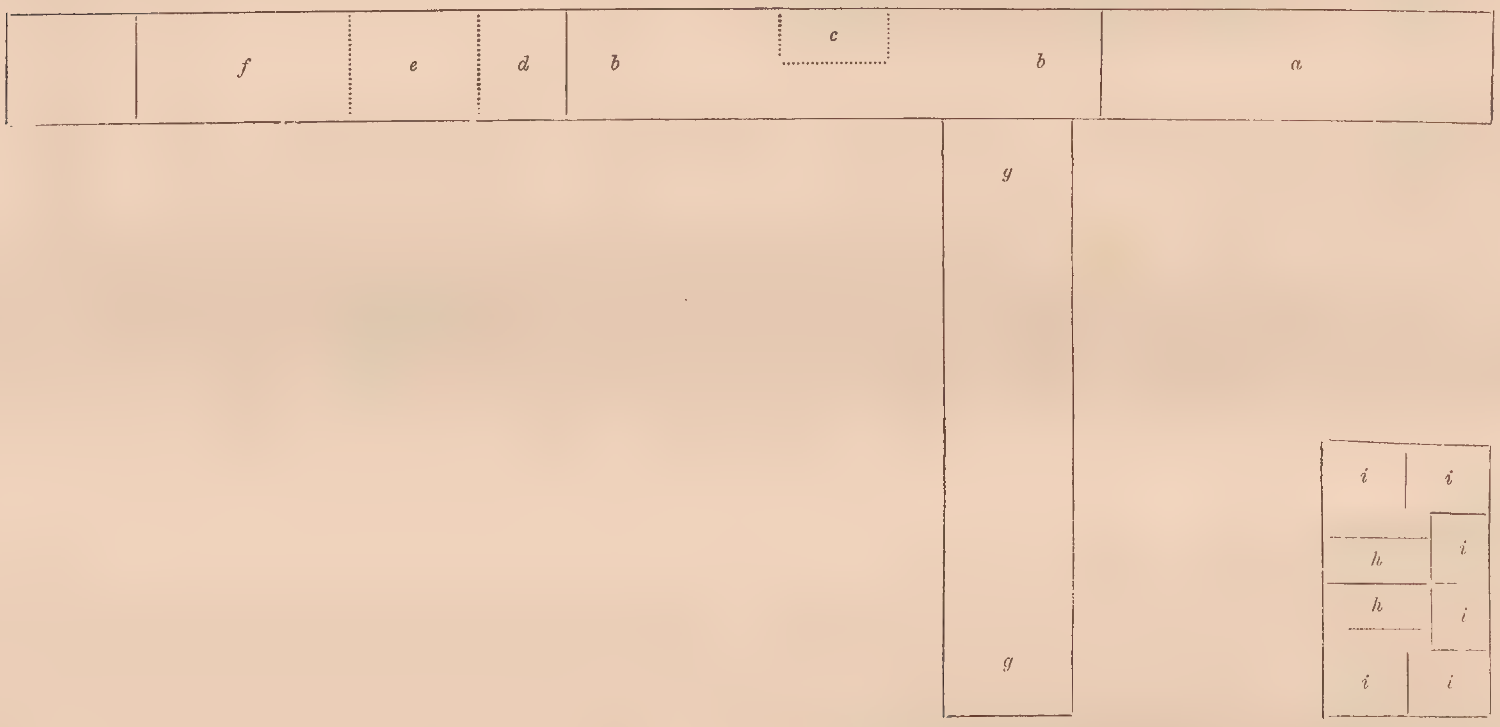
47. In fig. 14 we give a sketch plan, showing the arrangements of the farm-steading erected on the estate of the Right Hon. Lord Kinnaird, and of which working drawings and specifications were sent by his lordship to the Journal of the Royal Agricultural Society of England, vol. xii., No. XXVII., 1851. In the sketch in fig. 14, *a a′* is the boiler-shed, 47 feet by 11 feet—the boiler is placed at *a′*; *b* the engine-house 11 feet by 10 feet; *c* the straw-barn, 20 feet square; *d* the cut straw-room, 20 feet by 9; *e* the chaff-house, 20 feet by 12 feet 6 inches; *f f′* corn-room, 21 feet by 20 feet; the stairs leading to upper floor are placed at the point *f′*; *g g* cart-shed, 59 feet by 10 feet; *h h* implement-shed, 59 feet by 10 feet; *i* hay and straw house, or space for loose boxes, 21 feet by 17 feet; *j j* loose boxes, 79 feet by 16 feet; *k* bull-house, 16 feet by 7 feet; *l l* loose boxes, 75 feet by 18 feet; *m m* space for tramway, on which trucks run, conveying food from turnip-cutting and cake-bruising room *m′*, 31 feet by 20 feet; *n′* is the corn-room and mill, 23 feet by 20 feet; stairs are placed in the corner *o′* leading to upper floor; *n* loose boxes, or piggery, 38 feet by 16 feet; *o* cow-byre, 25 feet by 16 feet; *p* loose boxes, 16 feet by 10 feet; *q* shelter-shed, 36 feet by 17 feet; *q′* cattle-court; *r* privy; *s s* work-horse stable for ten horses, 64 feet by 18 feet; *t* gig-house, 12 feet by 9 feet; *u* riding-horse stable, 12 feet by 9 feet; *v* blacksmith's shop, 22 feet by 18 feet; *w* tool-house, 18 feet by 11 feet; *x x* the kitchens of the cottars' houses, 18 feet by 12 feet; *y y* the porches; *z z* stairs to bed-room floor; 1 2 pantries. In fig. 15 *a* is the grain-loft; *b b* the sheaf-loft; *c* the thrashing-machine; *d* the drying-room; *e* the corn-room; *f* the grinding-room; *g g* the stable-loft; *h h* stairs of cottars' houses; *i i*, *i i*, *i i*, *i i*, the bed-rooms.

Fig. 14.



Sketch showing arrangement of Farm Steading erected on the estate of the Right Hon. Lord Kinnaird.

Fig. 15



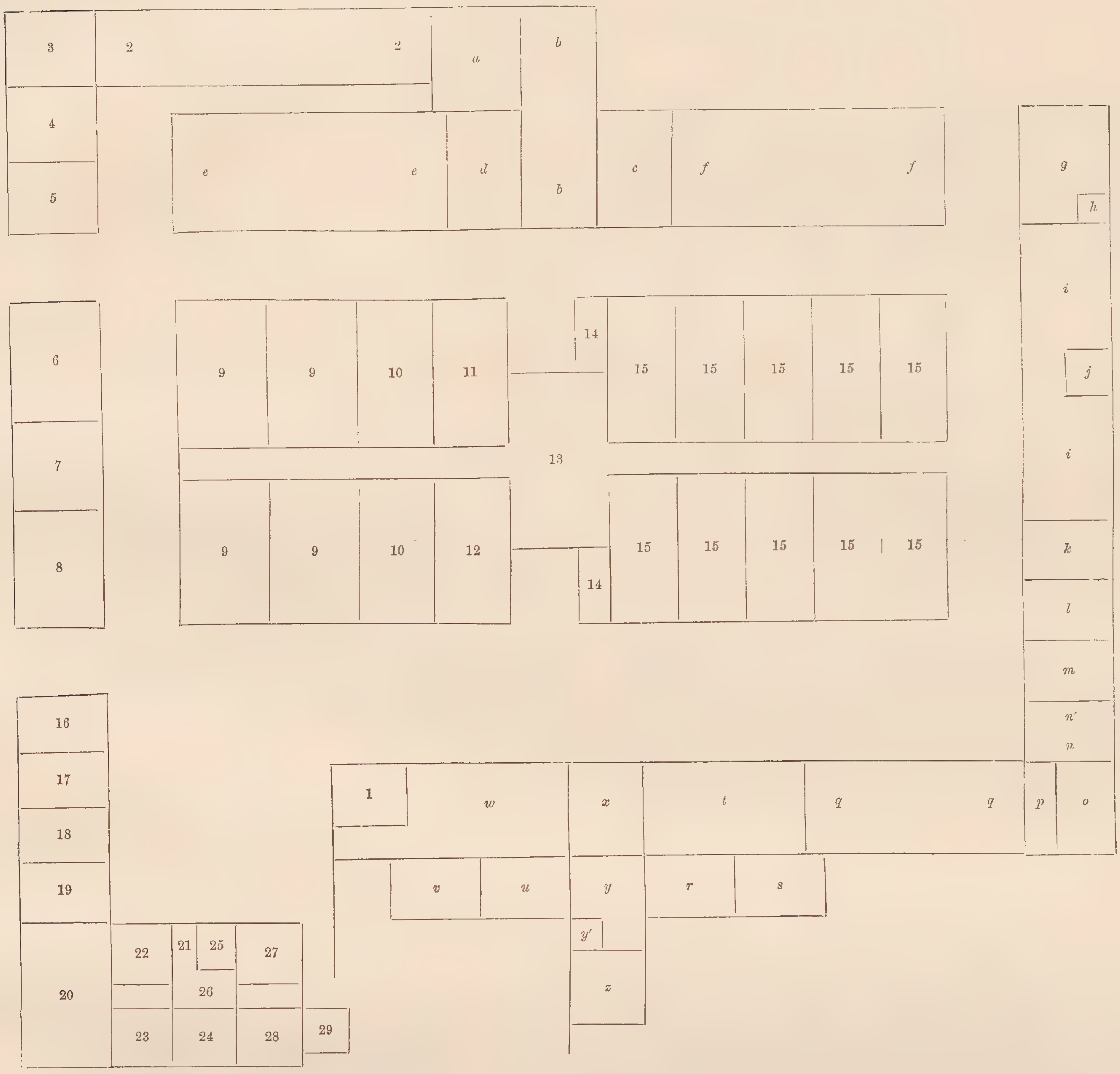
Sketch of Upper Floor of Steading in Fig. 14.

48. In fig. 16 we give a sketch showing the arrangements of the steading erected—from the designs of Mr. G. Dean—at Lymm, Cheshire, and a plan of which is given in the Journal of the Royal Agricultural Society, vol. xi., 1850. In our sketch *a* is the engine-house; *b b* the barn; *c* chaff-house; *d* provision-shed; *e e* double range of cattle-boxes; *f f* ditto, with tramway in the centre of each between the ranges of boxes; *g* dung-pit; liquid manure tank at *h*; *i i* work-horse stable; *j* corn and harness room; *k* gig-house; *l* infirmary; *m* spare shed; *n* dung-pit; *n′* liquid manure tank; *o* calf-shed; *p* provision-shed; *q q* cow-boxes; *r* turkey-house; *s* goose-house; *t* poultry-yard; *u* hen-house; *v* feeding-house; *w* poultry-yard; *x* dairy; *y* scalding-room; *y′* boiler; *z* duck-house; 1 slaughter-house; 2 2 implement-shed; 3 blacksmith's shop; 4 carpenter's shop; 5 dung-pit; 6 carts and waggons; 7 provision-shed; 8 carts and waggons; 9, 9, 9, 9, stock-yards; 10 10 sheep-boxes; 11 spare shed; 12 sheep-fold; 13 boiling-house; 14 14 food-tanks; 15 15 piggeries; 16 drill-house; 17 tool-house; 18 men's room; 19 office; 20 garden; 21 entrance, and 26 passage to house; 22 sitting-room; 23 dining-room; 24 kitchen; 25 pantry; 27 salting and drying house; 28 scullery; 29 coals.

49. Of late years, what are called *covered homesteads* have been greatly advocated by some. In these the whole of the apartments are under one roof. Lord Kinnaird was amongst the first to introduce into practice a steading of this kind on the large scale; and he states that he has derived great benefit, and effected much economy in the working of his farm, by the adoption of the system. "Detached buildings," he remarks, "with large and small courts—outer and inner courts extending over a considerable area of ground, expensive in original construction, and entailing a daily waste of labour, farm produce, and time consumed in traversing from one yard to another, are faults which I have found in most farm-buildings I have visited." The arrangement shown in the plan, of which, in fig. 17, we give a rough sketch, "enables," says his lordship, "100 cattle to be fed with greater ease by one man than the 30 usually allotted to him, with the personal convenience of being at all seasons under shelter. A steading entirely covered in, effects a great saving in farm produce, which must otherwise be exposed to the injurious effects of the weather, while the amount consumed and destroyed by the stock is considerably less."

50. In fig. 17, the ground plan, *a* is the straw-barn, 20 feet by 22 feet; *b* the chaff-room, 5 feet wide at its narrowest, and 15 feet at its widest part; *c* the corn-room, 19 feet by 22 feet; *d* stairs, 5 feet wide; stairs 3 feet wide are placed at the corner *a*, in barn *a*; *e* implement-shed, 40 feet long by

Fig. 16.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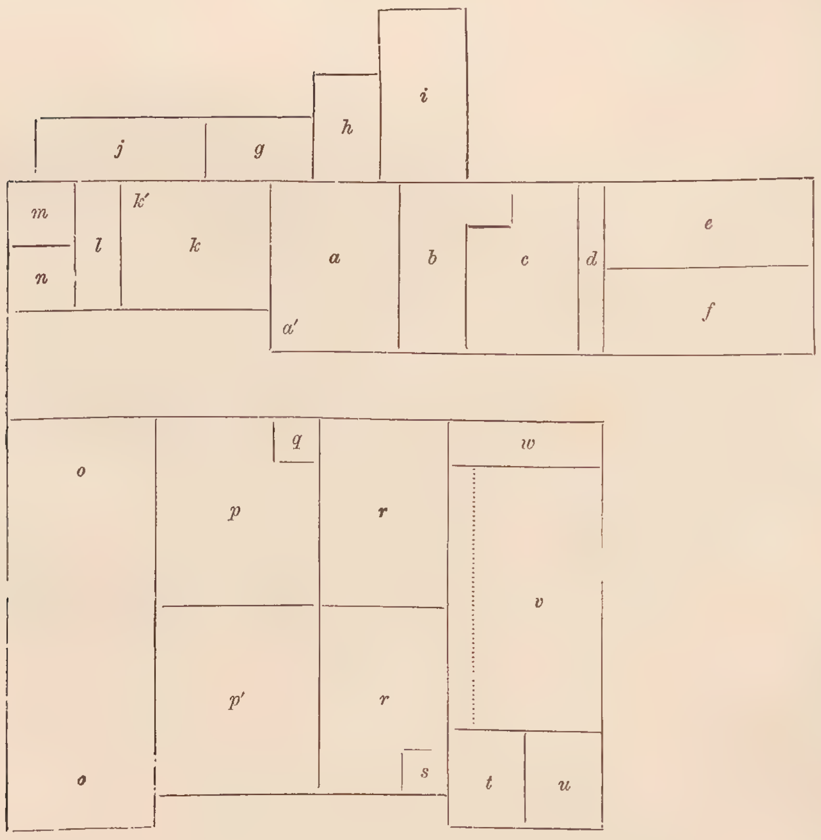
Sketch of general Plan of Farm-stead, Lymm, Cheshire, erected for T. Ridgway, Esq.—Scale 32 feet to an inch.

Fig. 17.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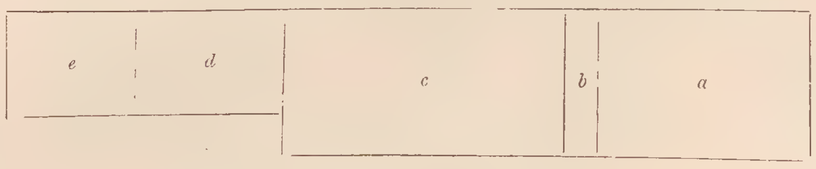
Ground Plan of Lord Kinnaird's Covered Homestead.

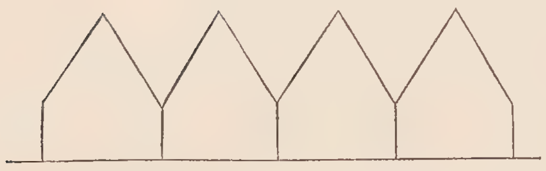
10 feet wide; *f* cart-shed, same dimensions; *g* boiler-house, 14 feet by 9 feet; *h* engine-house, 12 feet by 8 feet; *i* straw-shed, 27 feet by 18 feet; *j* turnip-shed, 34 feet by 9 feet; *k* shed for cut turnips and prepared food, 28 feet by 15 feet; *l* store, 15 feet by 10 feet; stairs to the upper floor are placed in the corner *k′* of apartment *k*; *m* the infirmary, 10 feet by 7 feet; *n* loose box, 10 feet by 7 feet; *o o* feeding-boxes for fattening stock, 74 feet by 22 feet; *p* feeding-boxes for young stock, 36 feet by 27 feet; *p′* byre or cow-house, 36 feet by 27 feet; *q* bull-house, 9 feet by 7 feet; *r* cattle and dung court, 74 feet by 22 feet; *s* privy; *t* riding-horse stable, 10 feet by 9 feet; *u* gig-horse ditto; *v* work-horse stable, 41 feet by 20 feet; *w* grass-house, 20 feet by 12 feet.

51. In the plan of upper floor, fig. 18, *a* is the grain-loft; *b* the stairs; *c* sheaf-loft and straw-barn; *d* chaff-cutter, and room for unprepared food; *e* cake-room, &c. The whole of the apartments are covered in with ridge and valley roof, thus—

Fig. 18.

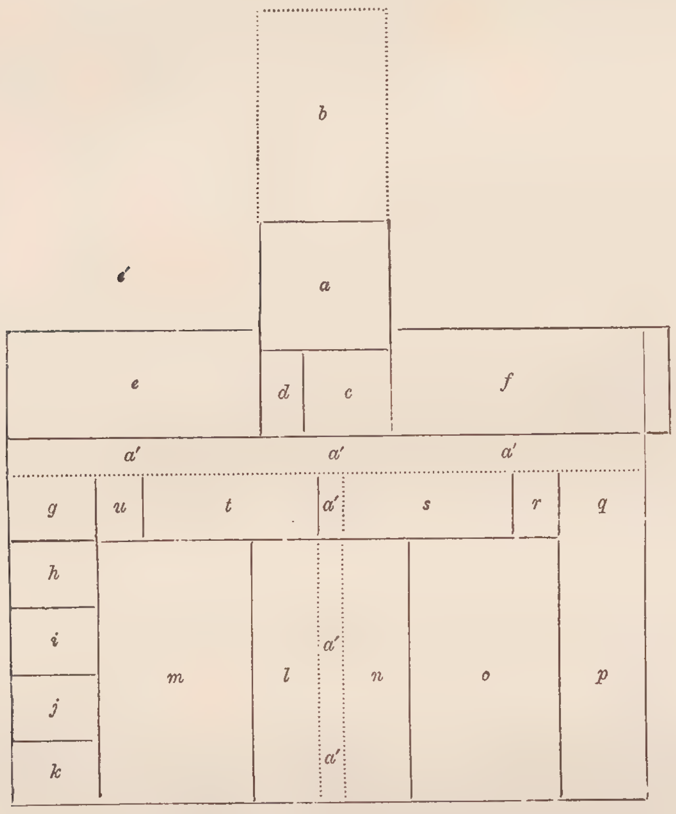


Upper Floor of Lord Kinnaird's Homestead.



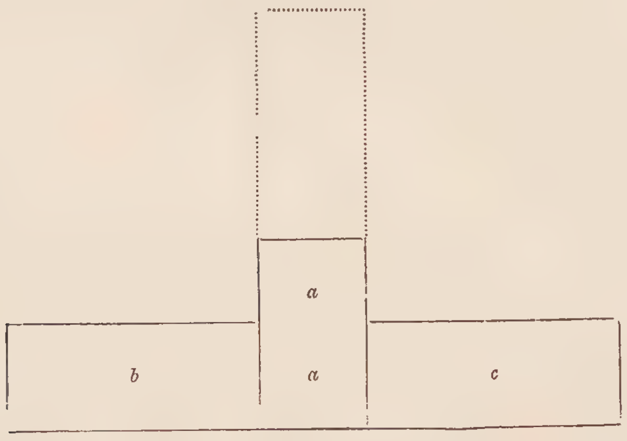
52. In the same number of the Journal of the Royal Agricultural Society of England, from which we have taken the above particulars of Lord Kinnaird's Covered Farm Steading, there is a paper from the pen of Mr. W. Fisher Hobbs, describing a covered homestead erected by Mr. Day, the architect of Worcester, for the Earl of Somers, at Knapp Farm, near Ledbury. In fig. 19 *a* is the corn-barn, 20 feet by 16 feet; *b* the skeleton-barn for unthrashed corn, or covered driving-way for three loaded waggons, 38 feet 6 inches by 18 feet; *c* root-house, 16 feet by 11 feet; *d* chaff-house; *e* straw-barn, 41 feet by 16 feet. The thrashing steam-engine (portable) is placed at *e′*; *f* cart and waggon lodge, 41 feet by 16 feet; *a′ a′ a′* gangway, 4 feet wide; *g* boiling-house, 16 feet by 12 feet; *h* the poultry-house, 16 feet by 8 feet; *i* spare house, 16 feet by 11 feet; *j* gig-house, 16 feet by 8 feet; *k* hack stable, 16 feet by 12 feet; *l m* yard for 10 or more bullocks or cows; *n o* ditto, ditto, each 40 feet by 32 feet; *p q* stable for work horses, 48 feet by 16 feet; *r* and *u* calf-houses, each 10 feet by 8 feet; *s* cattle-boxes, 12 feet by 10 feet each; *t* pig-boxes, 10 feet by 6 feet each. In the plan of upper floor, fig. 20, *a a* the thrashing-floor; *b* upper part of straw-barn; *c* granary.

Fig. 19.



Sketch of Ground Plan of Knapp Farm.

Fig. 20.

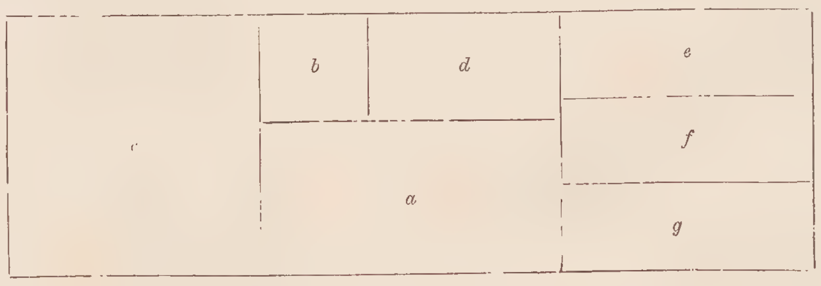


Sketch of Upper Floor of Knapp Farm.

53. *Steadings for Small or Amateur Farms—Continental and American Farms.*—Before giving our remarks on the constructive details, dimensions, and fittings of the various apartments of farm buildings, it may serve some useful purpose if we present a few sketch plans, showing the arrangement of steadings adapted for amateur farms, or the farms of small proprietors, as well as plans showing the arrangement of Continental and American steadings.

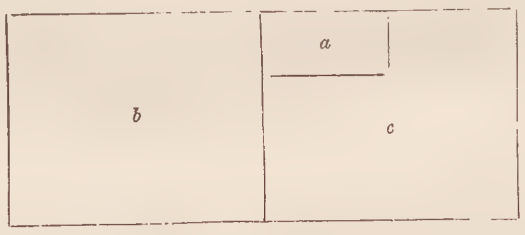
54. In fig. 21 we give a sketch of the ground plan arrangements of a six or eight acre farm-steading, in which *a* is the barn; *b* space for stairs; *c* cow-house for two cows; *d* corn and oil-cake store; *e* store piggery; *f* piggery; *g* poultry-house. In fig. 22 is the plan of upper floor; *a* space for stairs; *b* hay-balk; *c* corn and straw room.

Fig. 21.



Ground Plan of a Six or Eight Acre Farm-Steading.

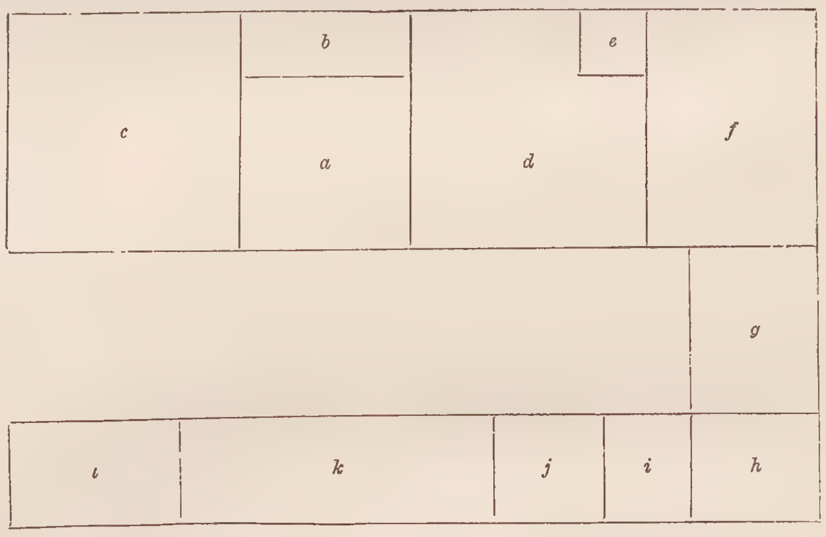
Fig. 22.



Upper Plan of Fig. 21.

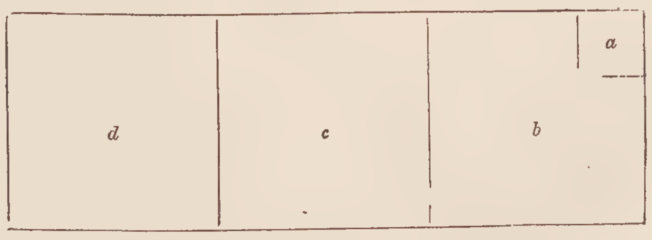
55. In fig. 23 we give ground-floor plan of a building for a ten or twelve acre farm, in which *a* is the barn; *b* straw-store; *c* cow-house for three cows; *d* stable for two horses, work and riding horse; *e* space for stairs; *f* root-store; *g* steam boiling-house; *h* calf-house; *i* oil-cake store; *j* implement-house; *k* piggeries; *l* poultry-house. In fig 24, the upper-floor plan, *a* is the space for stairs; *b d* hay-balks; *c* corn and straw-balk.

Fig. 23.



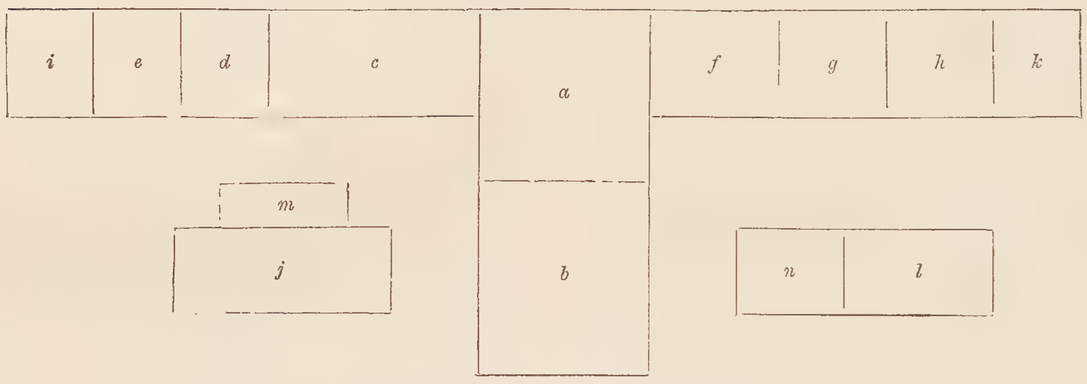
Ground Plan of a Ten or Twelve Acre Farm Steading.

Fig. 24.



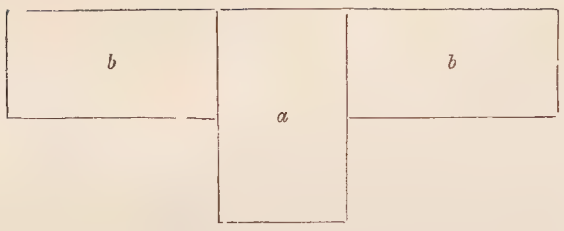
Upper Floor of Fig. 23.

Fig. 25.



Ground Plan of Steading for 20 to 25 Acres.

Fig. 26.

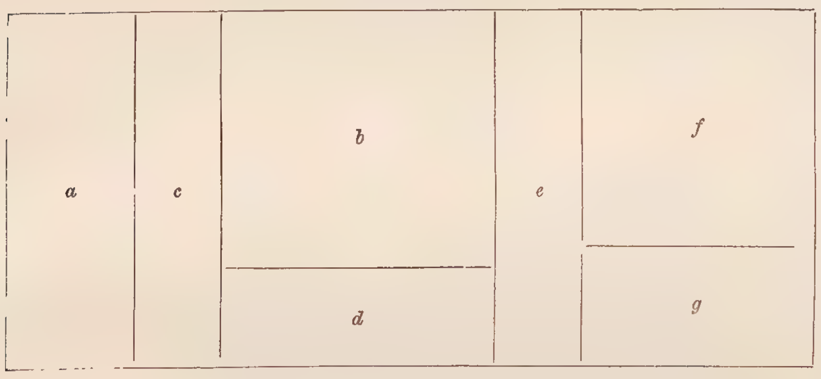


Plan of Upper Floor of Fig. 25.

56. In fig. 25 we give ground plan of steading for farm of from 20 to 25 acres, in which *a* is the barn; *b* straw-barn; *c* cow-house; *d* hay-house; *e* cooking-house; *i* oil-cake and meal store; *f* stable; *g* hay-house; *h* cart-house; *k* implement-house; *j* piggery; *m* turnip-store; *n* poultry-house; *l* poultry-yard. In fig. 26, the upper floor, *a* corn-balk; *b b* hay-balks.

57. In fig. 27 we give ground plan of a Dutch Barn, or "Low Country" Farm Steading, in which *a* is the cow-house; *b* the barn for corn in the sheaf; *c e* thrashing-floors; *d* stable; *f* corn-store in the sheaf; *g* cart-house.

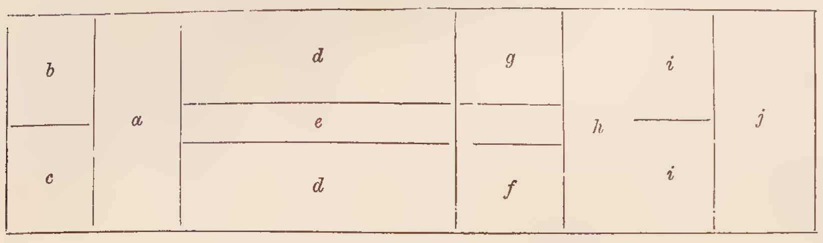
Fig. 27.



Ground Plan of "Dutch Barn," or Farm Steading.

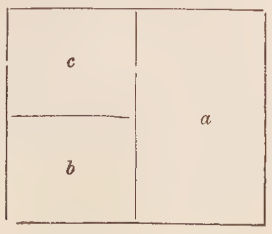
58. In fig. 28 we give ground plan of a Flemish (Belgian) Farm Steading, in which *a* is the kitchen; *b c* the bed-rooms; *d d* the cow-stalls, with feeding-passage *e* between them; *f* stable; *g* pigs; *h* thrashing-floor; *i i* corn in the sheaf; *j* cart-shed. In the cellar plan, fig. 29, *a* is the dairy; *b* the root cellar; *c* kitchen cellar.

Fig. 28.



Ground Plan of Flemish Farm Building.

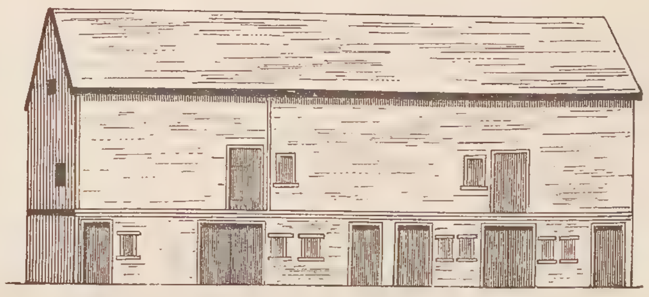
Fig. 29.



Cellar Plan of Fig. 28.

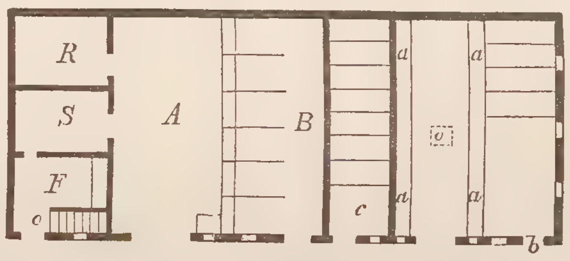
59. The distinguishing feature of North American Farm-buildings is the large barn designed to secure the crops from the inclemency of the severe winter of that climate. In fig. 30 we give a view of an American barn, erected on the estate of Mr. Sayer, near Newbury, on the banks of the Hudson, in the State of New York. Fig. 31 shows the plan of the basement, or ground floor, in which *A* is the carriage-house; *B* the work-horse stable; *c c* the cow-house, with feeding-passage *b b*, 11 feet wide; the hay is supplied to this passage and the mangers *a a a a* from the loft above, through the hole *o* in the floor—see fig. 32. The stalls measure 3 feet 2 inches from centre to centre of the divisions, and the cow-house affords accommodation for 18 cows. The stable *B* is 14 feet wide, having stalls 5 feet wide for six horses. The carriage-house *A* is 14 feet wide; in the right-hand lower corner of this house the position of the pump is shown. A small root-cellar is shown at *R*; *S* a straw-room; *F* a loose box for a spare or ill cow or horse. The stairs leading to upper floor are shown at *o*. In fig. 32 the main floor is shown at *A*, the width of this being 12 feet; *o* is the well-hole, through which the hay is pitched to the cow-house *c c*, fig. 31, below; *a a* are the hay-mows. The thrashing-floor, 14 feet wide, is at *c*; the straw is thrown through the opening at *c* to the straw-

Fig. 30.



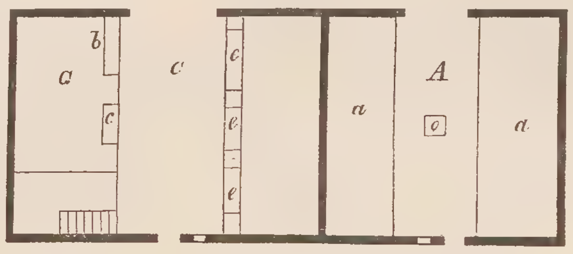
View of an American Barn, or Farm Building.

Fig. 31.



Basement Plan of Barn in Fig. 30.

Fig. 32.



Plan of Upper Floor of American Barn.

house *S* in the floor below (see fig. 31). The roots, as turnips, are thrown into the root-cellar *R* (see fig. 31); through the openings *e e e* the hay is supplied to the horse-stable below. The grain mow is at *g*. For these illustrations we are indebted to Mr. Downing's clever work, "The Architecture of Country Houses," published by Appleton & Co., New York.

60. *Fittings and Dimensions of the Various Apartments of Farm Buildings.*—Before proceeding to the consideration of this important department of our paper, it will be useful to give here the suggestive remarks of Mr. Elliott on the cheapest and best mode of carrying out durable constructions of farm buildings. These remarks were given in the course of a paper recently read on Farm Buildings before the Royal Agricultural Society of England:—

> "The locality must determine, in many cases, the cheapest materials to be employed; and this will also to some extent regulate the method of construction. The corn and hay stores, the engine-room, and the granary, will be the only parts requiring thick walls, whether of brick or stone, and heavy timbers. The box system being a multiplication of similar parts, it is advisable, as a principle, to construct them with details of simple form, of small scantlings, and few in kind, so that they can be easily put together, and easily replaced when damaged, while capable of extension or alteration, and variation of use—points of great importance, for which the box system offers great facilities, and which I have endeavoured to embody in the design now laid before you. Mr. Elliott then proceeded to say that the principle which had been followed in the plan lying on the table, and to which his previous remarks related, was identical with that submitted by Mr. Blundell of Bursledon in 1850; but they had dispensed with the open yard, and had brought the buildings into one block in the centre. Brick was used for the outside walls, iron for the internal divisions, and corrugated iron for the roofs. The new buildings had the advantage of being fire-proof, and of being quite as cheap as farm-buildings constructed in the ordinary manner. There was no lead in any part, except the dormer of the engine-house, which abutted on the farm-buildings. Lead was costly, and liable to be stolen; and his object was to construct the buildings in the cheapest manner consistent with durability. The engine was so situated that its action could be communicated to every part of the building where its power was required. Twenty-two bullocks could be accommodated in feeding-boxes. There were feeding-boxes for sows and pigs, and separate boxes for the boar and bull; and there was a dairy-house, with a small yard for the cows. The horses were on the other side of the building, and the passage giving access to them was 11 feet wide, so that on one side it would be available for harness. The method of paving the boxes, which had answered very well, was to fill them with a concrete composed of gravel and tar. When gravel had been mixed with a certain proportion of tar, fuel was applied and set fire to. After it had been burning about twenty-four hours, more tar was added. It was then applied to the surface, and left to harden; and it became as hard as asphalte. It had been satisfactory on the footpaths at Portsmouth and Southsea."

61. *Stables.*—The floor of the stable is the first point to be considered; and here, at the outset, it is necessary to say that it is a disputed point amongst farming authorities whether the floor of a stable should be level or inclined. A slight inclination of 3 inches in the whole of the length of the stall—9 feet—is recommended; but it is worthy of remembrance, as well pointed out by that shrewd authority in farming matters, Mr. Henry Stephens, that when horses have a freedom of choice they invariably prefer to stand upon level ground. The desiderata in the floor of a stable are hardness and roughness of surface, the former to resist the action of the horses' feet, the latter to prevent their slipping; to these must be added a capability to resist the absorption of the urine. An excellent floor can be made of bricks set on edge; and if of unequal width, the narrowest should be placed between two of the broadest ones, thus affording foot-holding for the horses. The desiderata for a stable floor are well met in Musgrave's Stable-Flooring Bricks, as illustrated in fig. 33. An excellent form of stable floor is that introduced by Mr. Forbes, and manufactured by Clayton of the Atlas Works, London; these are illustrated in Plate XXXI. They serve the purpose of drainage bricks. The gutter of a stable is placed immediately behind the stall post; it should be smooth on its upper surface, and should have a gentle fall to the outside of the wall, where it should communicate with the drain leading to the liquid manure tank. The old-fashioned form of open gutter is fast becoming disused, and is being rapidly replaced by the closed gutter, or drain-tube, the liquid reaching the interior of the drain-tube through gratings placed at intervals in the open gutter running along the foot of stalls. These gratings, in the best constructions, are trapped, which prevents the issue of bad smells from the drains to the interior of the stables. The stalls are generally placed in stables so that the heads are right against the back wall. There is no doubt that this plan is not so beneficial as where a feeding-passage is placed running along the heads of stalls, as in the following type diagram, fig. 34. The stalls are divided from one another by what are called *travises*—evidently a corruption of the word *traverse*. One of these is shown in the left-hand building in fig. 8, p. 7, of this Essay. It is made up of boards running horizontally, and tongued and grooved; they are supported by the "head-post," placed 18 inches from the wall, or against the wall, as shown in fig. 8. The head-post is made up of two battens, 4 inches by 2½ inches; these battens hold the ends of the travis-boards between them. The upper ends of the "head-posts" are secured to the joists of the roof or truss of the stable; while the lower end is mortised into holes made in the stone-rest, which should run from head to foot of the stall. On the upper side of this rest a groove should be cut, to admit of the lower board of the travis being placed in it. This is a much better plan than to place the lower board of the travis immediately in contact with the floor of the stall, exposed to all the wet of the litter. The end of this stone-rest nearest the gutter is provided with a hole, into which the lower end of the "heel-post" (see fig. 8) is fixed, the upper end of which is secured to a beam running along the whole length of the stable. The heel-post should be made circular, say 5 or 6 inches in diameter; if rectangular, the corners should be rounded off to prevent accidents to the horses. All angles should, indeed, be rounded off, and "bull-nosed" bricks used at the jambs of all doors opening into stock-houses. The thickness of the travis-boards should be 1½ or 2 inches, the

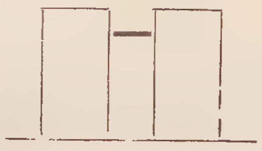
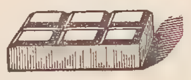
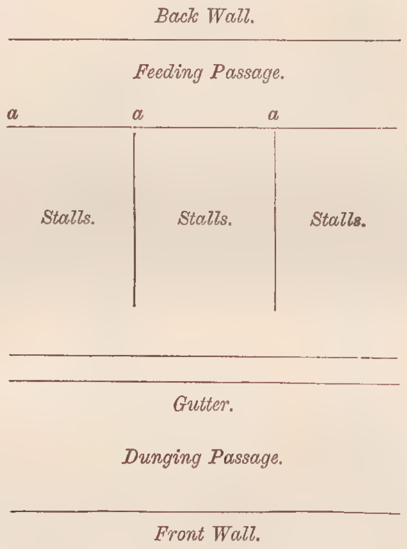


Fig. 33.



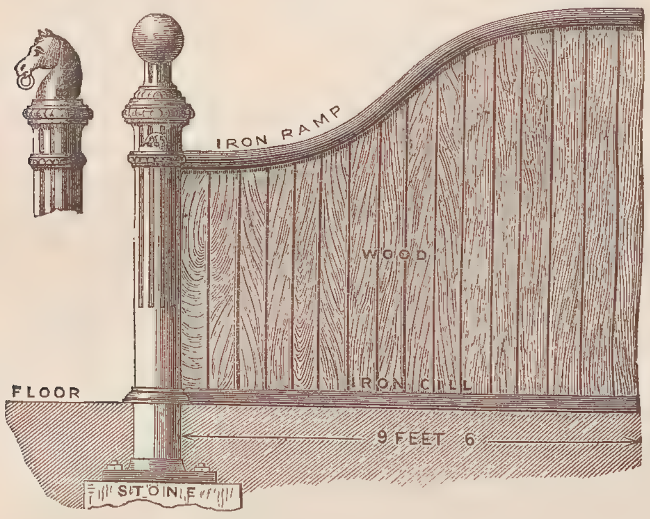
Flooring-Brick for Stables.

Fig. 34.



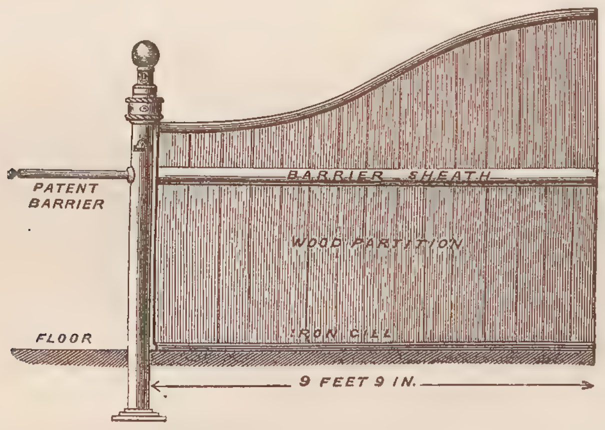
height at the end nearest the "head-post" 7 feet, and at "heel-post" 5 feet 6 inches. The upper edge of travis is usually curved in outline, as shown in fig. 8, and finished off either with an oak rail or with a strip of iron with rounded edges. In cases where a feeding-passage is placed at the heads of the stalls, as in fig. 34, the "head-posts" are placed at intervals corresponding to the width of the stalls, as at *a a.* The space between these posts at head of stalls should be made up of boards to a height of 5 feet, to keep undue draughts from the horse's head, and to admit of a sliding door being made, through which the hay and food are passed to the racks and mangers. In fig. 35 we illustrate the method of combining iron and wood in the construction of stable travises, as introduced by Messrs. Musgrave & Brothers, Ann Street Ironworks, Belfast; and in fig. 36 another form in which is adapted a barrier sheath. In this is placed a rod which can be pulled out on either travis, forming a very readily made "loose box."

Fig. 35.



Stall Division or Travis of Wood and Cast-Iron.

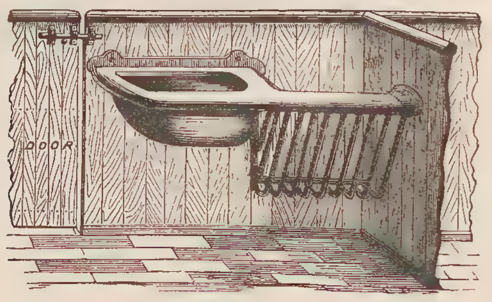
Fig. 36.



Stall Division with Patent Barrier.

The *position of the hay-rack* is one of the disputed points of stable architecture; some advocating the high position for it, so that the horse in eating will have to raise its head in order to pull out the hay; others advocating the low position as the best. A due consideration of the natural features connected with the horse while feeding will, we think, result in showing the great advantages of the low position of the rack. Fig. 37 shows the mode of fitting up a small court with a rack and manger, as introduced by the Messrs. Musgrave.

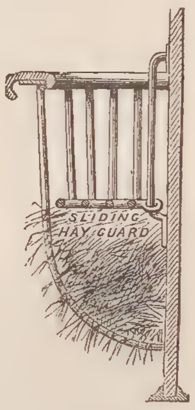
Fig. 37.



Hay-Rack and Manger.

The same principle of arrangement is also applicable to stable stalls. From the open hay-rack, as in fig. 37, the horse while eating is apt to pull out much of the loose hay, and scatter it abroad and waste it in his stall. Various forms of fittings have been introduced to prevent this being done. In Bruce's stable fittings, as manufactured by Messrs. Ransomes and Sims of Ipswich, a self-acting hay-rack is introduced. This consists of a rack in the corner of the stall made up of vertical bars, with a horizontally barred top. The hay is kept continually pressed up against this barred top so tightly that the horse cannot pull out any as loose stuff, and this by the following simple means. The hay rests upon a moveable platform, which slides up and down within the rack, and is kept acted upon by weights, which are connected to the ends of chains which pass over pulleys, and are fixed to the platform on which the hay rests. In fig. 38 we illustrate in section Messrs. Musgrave's sliding hay-guard, which in a simple manner secures the hay firmly against the sides of the rack.

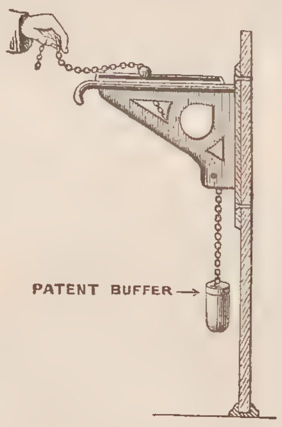
Fig. 38.



Sliding Hay-Guard.

In the old-fashioned mode of fitting up stables, the manger is placed immediately under the hay-rack; and to a ring fixed in front, and in centre of manger, the "horse-tie" is attached. The rope or halter from the horse's neck passes through this ring, and is provided at its lower end with a weight. The object of this weight is to keep the rope taut and out of the way of the horse; if loose, the probability is that his fore-feet would get entangled in it, and serious accidents ensue. In fig. 39 we illustrate Musgrave's horse-tie, in which an india-rubber ring is attached to the upper end of balance weight, by which the noise is deadened as the horse pulls the weight up against the bottom of bucket.

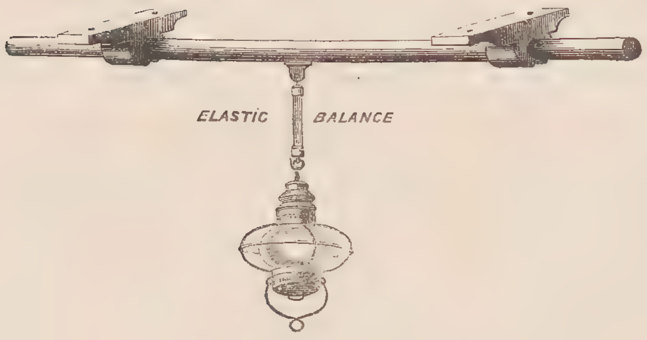
Fig. 39.



"Horse-Tie."

Ventilation is of the utmost importance in a stable; of the details of this desideratum we are not required here to go into; in connexion with it the reader will find ample matter in Essay Fifth, which takes up the whole subject. Of all the modes yet introduced for *lighting* stables, that invented by the Messrs. Musgrave of Belfast, to whom we are indebted for illustrations of so many admirable fittings of stock houses, is by far the simplest and the safest; we illustrate the mode in fig. 40; a hollow rod is made to run from one end of the stable to the other; and in the lower side of this a slit is made; a catch slides along this,

Fig. 40.

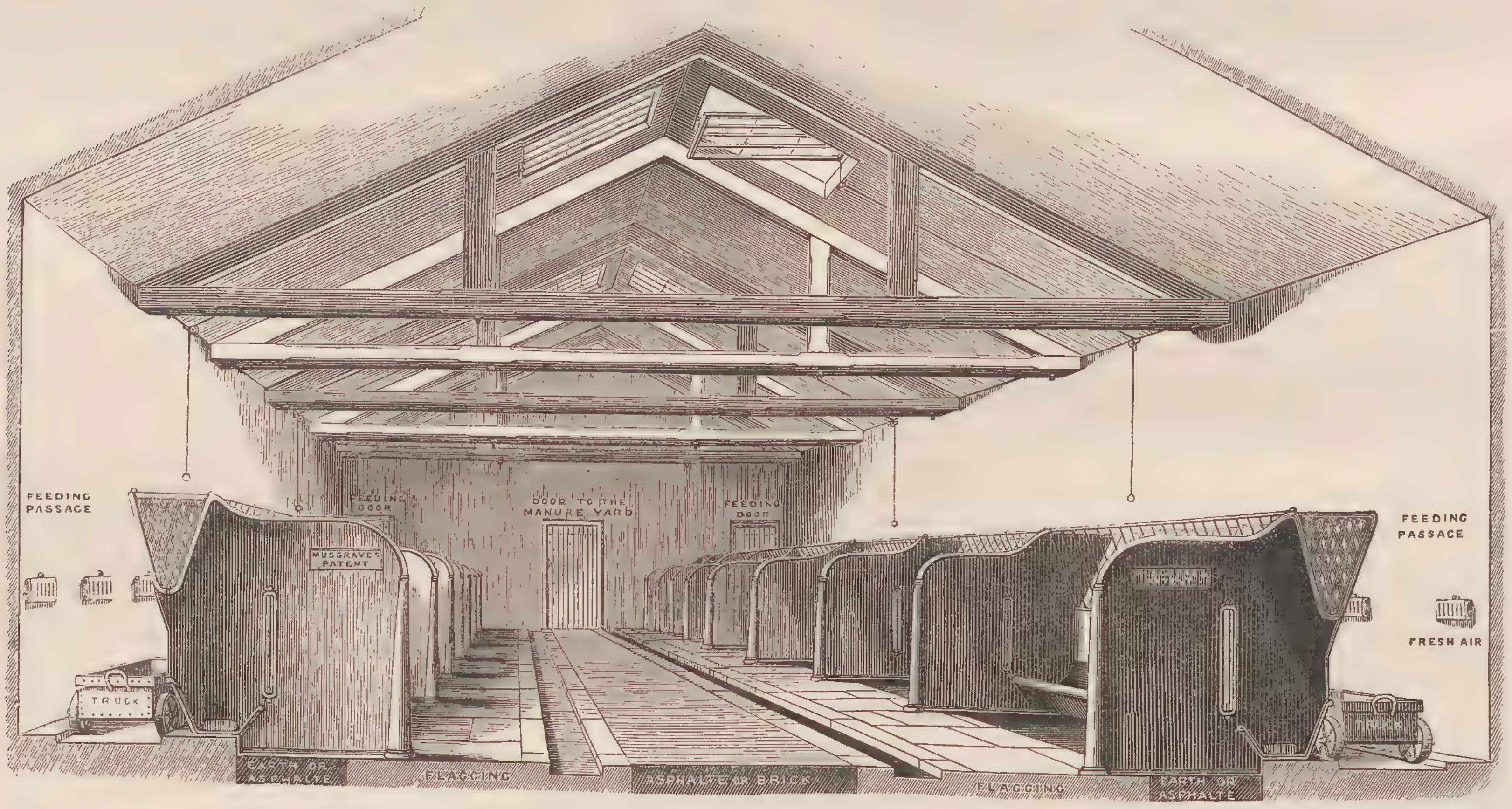


Lantern Slide for Stables.

and is connected by means of an elastic balance with the stable lamp as shown. The lamp can instantly be moved from one part of the stable to another. Where hay-racks and mangers are made of timber—in cases where there is plenty of home timber obtainable—the following notes of *dimensions* will be useful. The distance of bottom rail of hay-rack from wall, 6 inches; scantling of rail, 4 inches by 3 inches; the scantling of top rail is the same, and its distance from the wall 2 feet, this will give a slope of the front bars of the rack of 18 inches. The front bars should be circular. They are, however, generally made flat, and fitted easily into the upper and lower rails. The dimensions of manger are as follows: 15 inches wide at top, 9 at bottom, and 10 inches deep, made of 1½ inch stuff, and—usually—stretching from side to side of stall. The *dimensions of stall* have not yet been alluded to; but in arranging these regard should be had more to the care and comfort of the animal than to the economization of space, a point of comparatively little importance in country districts, where ground space is easily obtained. The dimensions, therefore, we would recommend are—width of stalls, inside measurement, 6 feet; length of stall from *front* of fittings, hay-rack, manger, &c., to front of the heel-post, 9 feet. The other dimensions of stable and stable-fittings will usefully close the paragraph; total width of stable, 18 feet maximum, 17 feet minimum; height from floor to ceiling, 10 to 11 feet; window width, 3 feet 6 inches, height, 4 feet 6 inches; width of door 4 feet 6 inches, height 7 feet 6 inches, with bull-nosed jambs. The dimensions of a loose box, 12 feet by 18 feet.

62. *Cow-Houses.*—Many of the points connected with the fittings of stables just discussed are obviously applicable to cow-houses. It should be noted, however, that the part of the stall from the front of the manger to the heel-post of travis must be comparatively soft, to prevent the knees of the cows being hurt when rising up or lying down. This part, therefore, may be boarded and covered, if deemed desirable, with Kamptulicon or with cocoa matting, or it may be made with earth well beaten down. The width of the stall for a single cow should not be less than 4 feet 6 inches, but 5 feet if possible; for two cows, 9 feet. We would, however, never recommend stalls for two cows to be adopted. A study of the habits of the animal will show that the best way by far is to give a stall to each cow; and let this stall be roomy enough. It is a great mistake to cramp animals up in a small confined space. The divisions or travises between the stalls are generally made of stone, as shown in the building to the right hand of fig. 8, page 7, of this Essay, the length being usually 6 feet, and height 3 feet. The best way of arranging the stalls of a cow-house is by giving a feeding passage at the head, as shown in fig. 8, page 7. Stalls are often placed foot to foot, with the dunging passage and gutters between. An excellent arrangement of a cow-house, as fitted up by Messrs. Musgrave, is illustrated in fig. 41, on the Ulster Model Farm.

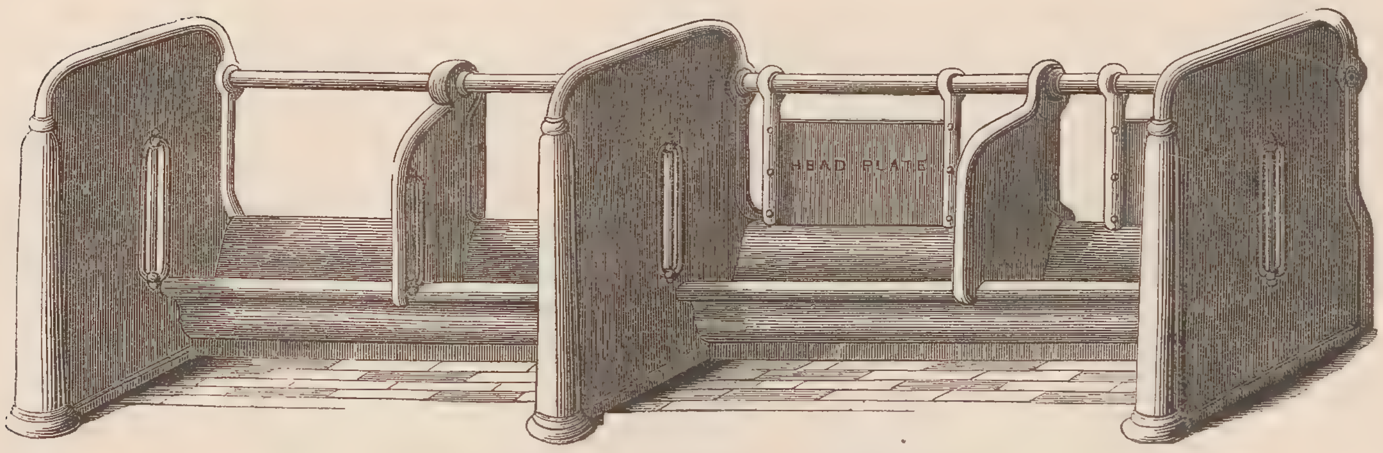
Fig. 41.



Interior View of Cow-House, with double range of Stalls, erected at the Ulster Model Farm.

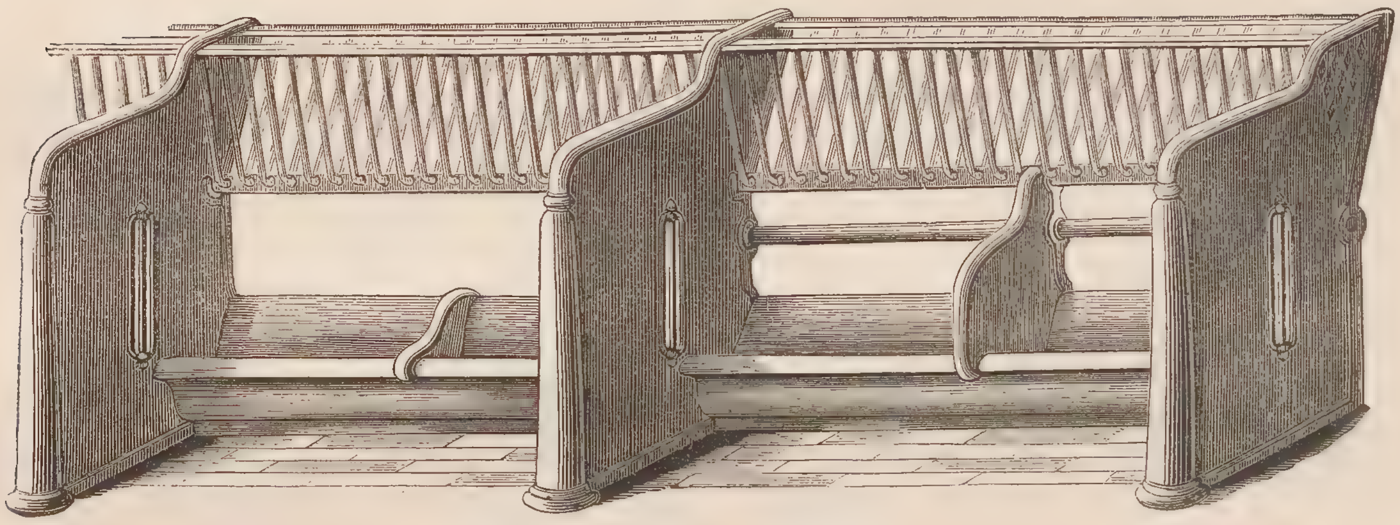
The mangers run from end to end of the stalls; and the supply of water is secured by a pipe and tap; a brass plug is fitted to one of the mangers nearest the drain. The feeding passages are provided with rails, on which the trucks run. Ventilation is secured by openings in the walls, and by swing skylights in the roofs, as shown. In figs. 42 and 43 we illustrate other modes of fitting up cow-houses, introduced by the Messrs. Musgrave. In fig. 42 the stalls are provided with mangers only, each stall being for two cows; dwarf partitions are made dividing the length of manger into two parts; while head-plates, as shown in the stall to the right, may separate the stall from the feeding passage. In fig. 43 racks are provided, which have this advantage, that the hay or grass is kept separate from the turnips or mash in the manger, and does not become heated or breathed upon by the cattle, which is often the case when the fodder and roots are all given to the cattle in the manger. Wood travises or divisions are thought more highly of by some authorities, as affording a material freer from damp, and more comfortable to the animal. The following *dimensions* will be useful for those who

Fig. 42.



Patent Cow-House Fittings, with Manger, but without Fodder-Rack.

Fig. 43.

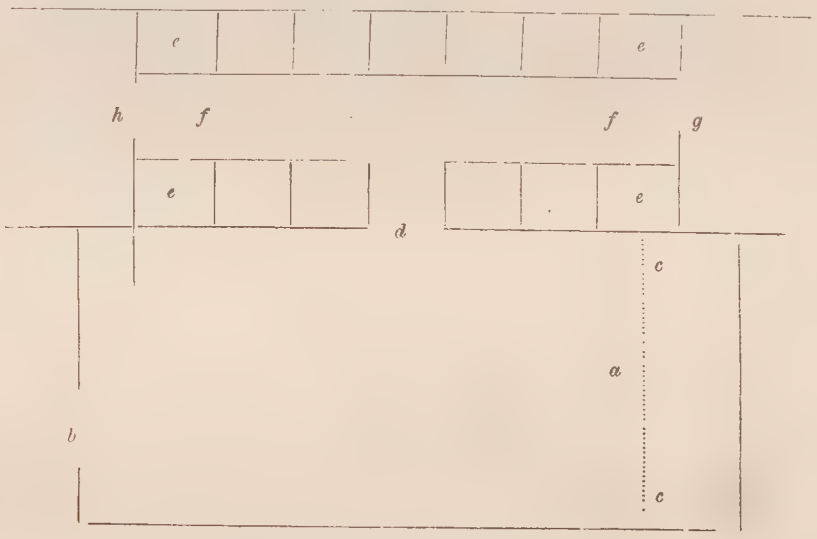


Patent Cow-House Fittings, with Fodder-Rack.

contemplate fitting up the stalls of home-grown or other timber, in place of purchasing the stall-fittings such as we have already illustrated. A stone curb, 6 inches deep, should run from end to end of stall, provided at the upper and lower end with mortice holes, into which the head and heel posts are fixed. The dimensions of these posts are—height 4 feet 6 inches or 5 feet, scantling 4 inches by 3 inches. The boards to be of 1½ inch plank, tongued and grooved, or dowelled and cramped, and the ends let into grooves made in the inner face of head and heel posts, and the lower board into a groove made in the face of the stone curb. The manger should rest upon a stone or brick base 18 inches high,—the dimensions of the manger, length 3 feet, or stretching from side to side of stall, depth 12 inches, width at top 15, and at bottom 10 inches; made of 1½ inch stuff. Each stall should be supplied with a water-trough; this may be made either of cast-iron, slate, or stone; and each should have a brass plug by which the water can be withdrawn from the trough at pleasure; and an overflow pipe by which the waste can be allowed to pass into the drain. A constant supply of water to the trough is advocated by the highest authorities as being the best for the animal, as it can thus drink when Nature prompts it. The cows are secured to the stalls in a variety of ways. An excellent plan is illustrated in figs. 41 to 43, in which a slot or vertical opening is made near the head of the stall, in the centre of which is fixed a rod, which passes through the ring to which the chain is attached. Another method, where the travis boards are of wood, is to make a rod of iron, with pointed ends, turned in at right angles to the length, the ends being driven into the travis boards near the head of stall, the ring being previously passed up the rod. The rod being thus free from the face of the travis boards, allows of ample space for the up and down movement of the ring and chain as the animal moves. Windows and doors of cow-houses and stables are illustrated in Plates XLIV. and XLV.

63. *The Calf-house.*—The position of this should be such as to secure ample light and fresh air, and a space before the door to admit of a small courtyard being enclosed. The house is usually fitted up with a series of small enclosures some 4 feet 6 inches square; the divisions between each being made by light frames or hurdles, the frame to the front being winged so as to open outwards like a door. The diagram in fig. 44,

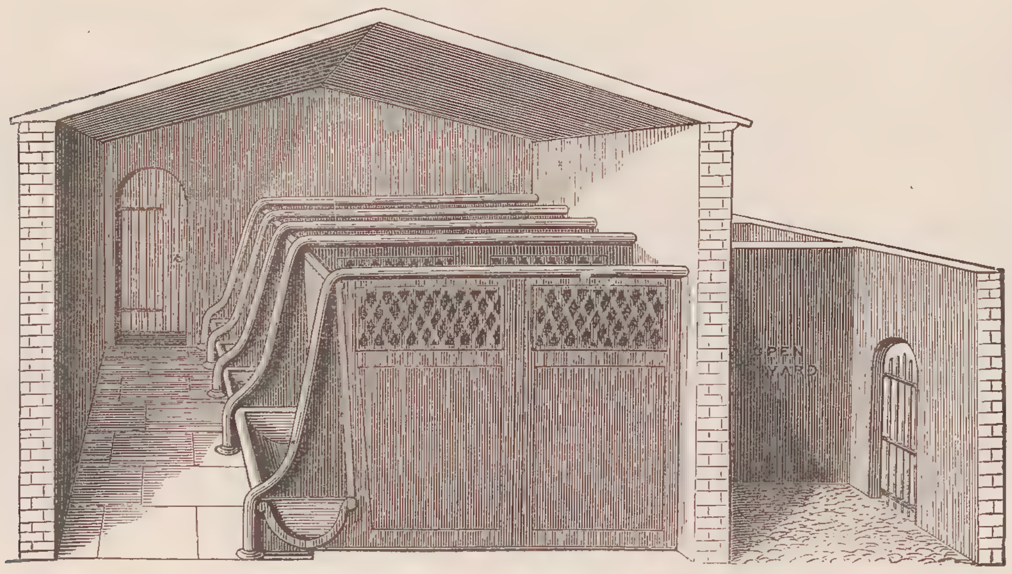
Fig. 44.



Plan of Calf-House and Courtyard.

in which *a a* is the courtyard, which is supplied with straw through the gate *b*, and through which also the dung is taken from the court; a shelter shed may be fitted up at one end, as shown by the dotted line *c c*; *d* the entrance to the calf-house, *e e e e* the calf-pens ranged on each side of the central feeding passage *f f*; *g* the door leading to the cow-byre, *h* to the root or food store. The floor of the calf-house should be paved or asphalted; and as calves pass a large proportion of urine, means should be carefully provided to lead it off as rapidly as possible. The best way to secure this is to make the floor of each pen or crib dish to a central point, at which a grating and trap should be placed leading to the drain which carries off the liquid to the tank. In fig. 45 we illustrate Musgrave's calf-house.

Fig. 45.

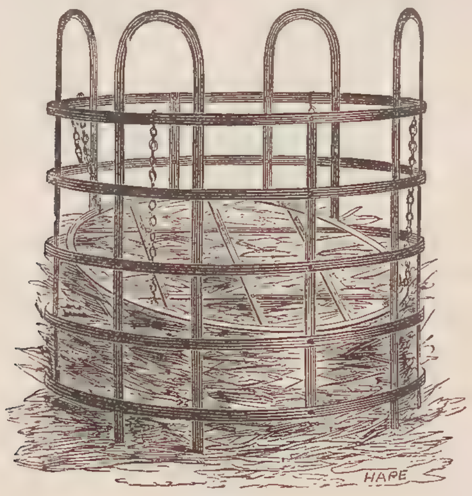


Musgrave's Calf-House, with Iron Stalls, Feeding Troughs, and open Yard.

64. *Accommodation for Feeding and Fattening Stock.*—There are four ways of accommodating feeding and fattening stock, all of which have their advocates—*first*, open courts and shelter sheds; *second*, stall-feeding; *third*, box-feeding; and *fourth*, hammel-feeding. Taking these in the order here named, we shall describe their peculiarities.

65. *Open Courtyards and Shelter Sheds.*—An arrangement of this mode of feeding stock is shown in fig. 7, page 6 of this Essay, in which 2 is the court, 3 the shelter shed, and 4 4 the turnip and water troughs. In Plate XXIV. an excellent arrangement of turnip stores and feeding courts and sheds is shown. In this the turnip store is placed between the two courts, the turnips being thrown through the port-holes left in the side walls of the turnip stores into the troughs in the side shelter sheds. For each animal kept a surface of floor in shelter shed of 60 feet should be allowed, and of 240 feet in the courtyard. The width of the opening into the shelter sheds should not be less than 5 feet 6 inches, and height 6 feet 6 inches or 7 feet. All jambs and corners should be rounded. It is a disputed point whether the floors of the courts should be drained. Some first-rate farmers prefer the liquid to be absorbed by the litter as it is pressed down by the stock; others to have the floor sloping from all sides to the centre, at which point is the entrance to the drain leading to the liquid manure tank. All courts should be provided with water and turnip troughs as shown in fig. 7, page 6 of this Essay, at 4 4, and racks for fodder; these being made of wood generally, and placed in the centre of the yard. Fig. 46 illustrates Musgrave's court fodder rack of iron, provided with a safety guard, which prevents the animals from pulling out the loose fodder and scattering it wastefully around.

Fig. 46.



Court Fodder Rack.

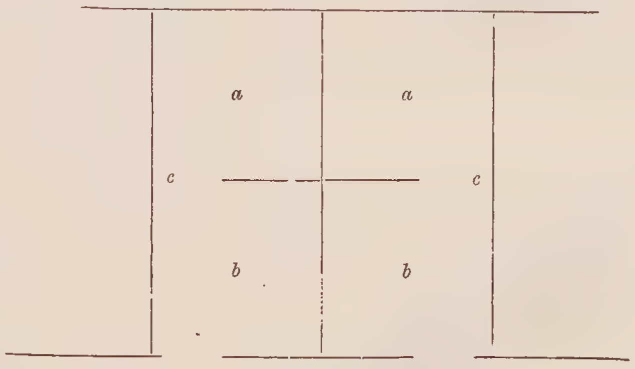
66. *Stall Feeding.*—We have little here to say on the details of fittings for carrying out this mode, the whole having been discussed in the paragraph on cow-houses (62). The system of stall feeding has many advocates, amongst which we name here the celebrated agriculturist, Mr. Caird, M.P., who thus records his opinion of it:—

> "A considerable comparative experience has convinced me that no other method will give equal accommodation for the same outlay, whilst I am persuaded that, in regard to economy of food and litter, facility of labour in attendance, health and progress of the cattle, and systematic arrangement altogether, stall-feeding is superior to any other that has yet come under my notice. The progress of the soiling-system, or house-feeding, feeding of cattle in summer as well as winter, will lead to a more general recognition of the superiority of stall-feeding, both from necessity of economizing litter, and the advantages of not wasting the labour of the cattle-feeders and others in traversing unnecessary distances while attending to the stock."

67. *Cattle-Boxes.*—This is perhaps the most extensively-used system in modern farm-buildings. In the plan in fig. 7, p. 6 of this Essay, $x\,x$ shows the ranges of boxes. There are, in fact, a range of "loose boxes," the division between each of which is made of a light gate, or hurdle, each box being provided with moveable mangers and troughs. The animal is confined in the box, and supplied daily with litter, which is not removed, but allowed to accumulate, being trodden down by the animal, and the heap is removed at intervals as desired. The height of the floor of the box is thus constantly changing, which does away with the plan of having fixed cribs or mangers. The measurement of each box varies from 10 feet square to 10 feet 6 inches square; some authorities give, however, as much as 120 square feet of floor measurement to each box. The floor should be made to dish from all points to the centre, this point being that at which the grating is laid leading to the drain to the liquid manure tank.

68. *Hammels.*—This system of feeding stock is simply a modification of the open court and shelter-shed system already described, accommodation being adapted to give space for two full-grown or three growing oxen, and consisting of a small open court or yard, *b b*, 14 feet by 18 feet; a shelter-shed, *b b*, 14 feet by 12 feet, or of dimensions calculated to give in

Fig. 47.



Hammels.

the courts a similar amount of superficial space. Each court is provided with a turnip and water trough and a rack. The opinions of the advocates of box-feeding and hammel-feeding respectively are well represented by the following extracts from authoritative works:—

> "The generally imperfect management," says Mr. Ewart, the author of a Treatise on Farm Buildings, "of fattening stock, and the negligent preparation of manure, so prevalent in times past, cannot enable the husbandman of Britain to meet, without diminution of capital, the unrestricted competition of foreigners in the British market in every kind of produce of the soil which he will henceforth have to encounter. The excrements of a few half-fed wintering cattle, and the litter of an open yard exposed to the alternate effects of rain, wind, and sunshine, will do little in raising such grain crops as to enable the British farmer to maintain, much less to promote, a profitable employment of his capital, and of native industry in the cultivation of the soil. . . . The essential conditions on which the fattening of cattle can be obtained with the greatest economy are warmth, quietude, wholesomeness of atmosphere, and cleanliness. And of all accommodations that have probably ever been invented for the feeding of oxen, none has so completely answered the principal object of converting the vegetable productions of the earth into food for mankind in the shape of flesh as the plan of feeding in boxes or loose stalls, first suggested by Mr. John Warner of Trimingham in Norfolk, nor does any plan more completely fulfil a secondary, but scarcely less important object, the raising of manure of the best quality with the greatest economy than the accommodation alluded to. There cannot exist in the mind of any individual who may have witnessed the feeding of cattle in boxes properly carried out, a doubt of its being a most effectual mode of providing due shelter, perfect freedom from molestation, and complete comfort to the animals—all conditions most essential to rapid thriving; nor can any one behold the accommodation without being thoroughly convinced of the great economy in collecting the egesta, and preserving it in the very best state for its purposes, and yet without the least exhalation of effluvia. Whatever may be supposed, those who have not seen the box-feeding system in operation are hereby assured by the writer, who has carefully watched the effect, that it is in every respect consistent with its perfect cleanliness and perfect health of the beasts, and he must, without hesitation, state his belief, that whenever any objection has been raised to the system, it has been induced from having seen boxes of improper construction and fitting, or perhaps from excess of moisture, produced from rain from above, or from springs from beneath. As to the latter observation, respecting excess of moisture, the writer is certain of the fact, that a sufficient quantity of dry litter, supplied three times a-week, to keep the animals clean from the solid excrement, is sufficient to completely absorb the whole of the urine they void."

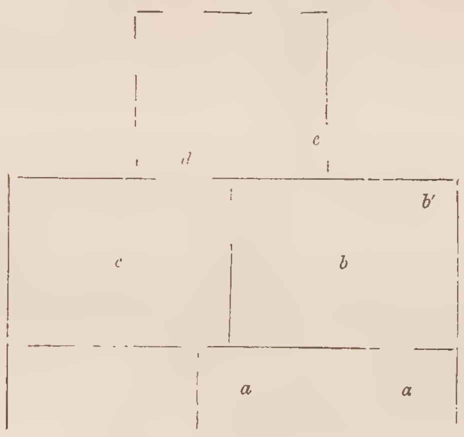
On the other hand, Mr. Stephens thus argues in favour of the hammel system:—

> "I am sure that exposure at will to the sun and air, and even rain in winter, is much more conducive to the health of an ox than constant confinement under a roof. It is true that box-feeding affords much more liberty to the animal than when feeding at a stake in a byre; but in what respects box-feeding should excel small hammels it is not easy to discover. The cost of constructing small hammels to hold two or three oxen together is not great—two is the number I would always prefer, as affording society, and avoiding contention on the one hand and loneliness on the other; but the cost of constructing accommodation for cattle I consider a secondary consideration in comparison to affording them the greatest comfort; and greater comfort than a hammel may afford is scarcely possible to be attained by any other means, certainly not by such boxes, and the manure would be equally as well compressed and good in hammels as in boxes."

69. *The Piggery.*—The usual form of pig-sties is shown at *r r* in fig. 7, p. 6 in this Essay; the inner, or shelter-shed, being 6 feet long by 4 feet wide; the court, or yard, being 7 feet by 4 feet, or thereabouts. The court is fitted up with a manger, or feeding-trough, and provided with a door. The arrangement in fig. 45 is admirably adapted for piggeries.

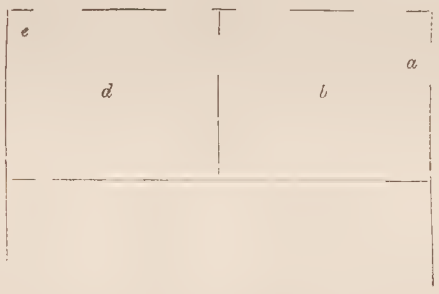
70. *The Dairy.*—This, in many farm-steadings, forms part of the farm-house; in others it is an isolated building, or made to form part of the steading. "The apartments required in it," as we have elsewhere stated, "are—1. milking-room 2. churning-room; 3. cheese-making room; 4. a wash or boiling-room, where water may be boiled and the utensils of the dairy washed; 5. a cheese-drying and storage-room. The aspect of the dairy should be north; but if this cannot be accomplished, due east must be obtained; a southern aspect is totally inadmissible. In fig. 48 we give the plan of the dairy part of a farm-house—*a a* the kitchen, with door leading into boiling and wash-house *b*; *c* churning-room; *d* milk-room, with external door *e*. Fig. 49 is the upper plan—*a* the stairs leading from boiling-room below; *b* the cheese-making room; *e* a lift in the corner, by which to bring up material from the milk-room below; *d* the cheese-storing room. If a convenient locality can be obtained at once near the farm-house and the cow-house, and yet completely away from all noxious smells, &c., of the farm-yard, where an isolated dairy can be erected, more satisfaction will be secured. It is unnecessary to give a plan showing an arrangement of this isolated dairy; the requisite apartments being secured in it, they will best be arranged by the architect according to his notions of convenience of working, or of those of his client. The floor of the milk-room, and the benches on which the milk-cans are placed, should be of slate, every pains being taken to secure coolness, and at the same time freedom from damp. Ventilation should be carefully attended to, many of the contrivances specially described in former papers being obviously applicable to this apartment. All breaks, as in cornices, skirtings, &c., should be avoided, as these only afford spaces on which dust lodges. All the internal fittings should be flush with the walls, and the corners of the room and the junction with the ceiling should not be at right angles, but made with curves. The windows, if possible, should be double, the outer one being made with perforated zinc, the inner one glazed as usual, and double hung with pullies and sash-lights. The churning-room and cheese-making room should also be fitted up in the same way, and the floor of the washing-house should dish from all sides to the centre, to permit all slops, &c., to drain rapidly away. Ventilation should be ample, to carry rapidly off, and preventing their finding access to the other room, all steam and vapour. A small open shed should be provided near the door of the wash-house, under the roof of which the utensils can be placed to dry and get the air."

Fig. 48.



Ground Plan of Dairy.

Fig. 49.



Upper Plan of Dairy

71. *The Corn-barn and Granary.*—The door of the corn-barn should be made in two halves, opening vertically; one of the leaves should be provided with a small door, cut horizontally into two portions, so that the upper half may be left open while the lower remains closed. An excellent form of door for barns is the sliding or rolling door; a door of this description, made of timber, is illustrated in Plate XLVI., and one of corrugated iron in Plate XLVII. The floor of the barn may be made of red pine, tongued and grooved, or of smoothly-polished flags, resting upon brick bearers. Every precaution should be taken to prevent damp, and the entrance and lodgment of vermin. The walls should be well plastered. In fitting up the granary great attention should be paid to the means for preventing the entrance of vermin. The floor should be boarded, and a cement skirting run all round; and ample light and ventilation secured by the louvre-boarded windows. The following remarks by Mr. Stephens will be valuable as to the means for preventing the ravages of vermin in farm-buildings.

> "Rats and mice being very destructive and dirty vermin in steadings, and particularly so to grain in granaries, means should be used in the construction of steadings to prevent their lodgment in any particular part. Many expedients have been tried to destroy them in granaries, such as putting up a smooth, triangular board across each corner, near the top of the wall. The vermin come down any part of the wall to the corn at their leisure, but when disturbed run to the corners, up which they easily ascend, but are prevented gaining the top of the wall by the triangular boards; and on falling down, either on the corn or the floor, are there easily destroyed. But preventive means in this case are much better than destructive, inasmuch as the granaries should always be kept free of them, and the grain will then only be sweet and clean. The great means of prevention is to deprive vermin of convenient places to breed in above ground, and this may be accomplished in all farmsteads by building up the tops of all the walls, and beam-filling between the legs of the couples (rafters) with stone and mortar, taking care to keep the mortar from contact with the timber. These places form the favourite breeding-ground of vermin in farmsteads, and should therefore be occupied with substantial stone-wall mortar. . . Besides the tops of the walls, rats and mice breed underground, and find access into apartments through the floor. To prevent lodgment in these places also, it will be proper to lay the strongest flagging and causewaying upon a bed of mortar, spread over a body of 9 inches of small broken stones, around the walls of every apartment in the ground floor where any food for them may chance to fall, such as in the stables, byres, boiling-house, calves'-house, implement-house, hay-house, pig-sties, and hen-house."

72. *The liquid manure tank* ought to form an appendage of every farm; there is no excuse for the waste of the liquid exuviæ of a farm, whatever excuse may be pleaded for the waste liquid refuse of town houses. The refuse of the town is said to be the wealth of the country; the difficulty is to get the refuse from the town, where it is a nuisance, to the country, where, properly applied, it is a benefit. This difficulty has no existence in rural districts; and it is a shameless waste, which admits of no palliation, to see the waste liquids of a farm running heedlessly away in place of being carefully stored up and used as a most valuable manurial resource. It is difficult to give exact data to guide the architect in deciding upon the dimensions of a liquid manure tank for a farm. The estimates of various authorities vary so much as to the daily quantity of liquid voided by each animal, while, so far as the waste waters of the household are concerned, it is perhaps still more difficult to give even an approximative estimate. We have elsewhere given the following—"Allow from 1,500 to 2,500 gallons for the household drainage according to its extent for the yearly amount, 800 to 1,000 gallons for each cow, 300 for each horse, and say 100 for each sow." Mr. Love gives, in his paper in the Journal of the Royal Agricultural Society of England—"The best means of applying liquid manure," the two following tables, which will be of some service to those constructing liquid manure tanks;—

TABLE I.

Depth over the Surface.	Gallons.	Cubic feet.	Tons.	Diameter of Tank.	
				Ft.	In.
0·1 of an inch	2,269	364	11·34	6	10
0·2 ,,	4,538	729	22·68	9	8
0·3 ,,	6,807	1,093	34·00	11	10
0·4 ,,	9,076	1,458	45·36	13	8
0·5 ,,	11,345	1.822	56·72	15	3
0·6 ,,	13,614	2,187	68·10	16	8
0·7 ,,	15,833	2,551	79·40	18	0
0·8 ,,	18,152	2,916	90·75	19	3
0 9 ,,	20,421	3,281	102·1	20	6
1·0 inch	22,690	3,645	113·4	21	7

TABLE II.

Quantity in gallons.	Depth of Tank.	Diameter of Tank.		Depth of Excavation.	Diameter of Excavation.		Cubic yards in Excavation.	Staunching clay in cubic yards.	Bricks for dome and bottom and walls—Standard size.	Total Cost.		
	Ft.	Ft.	In.	Ft.	Ft.	In.				£	s.	d.
2,269	10	6	10	12	9	0	28	5⅔	4,200	8	6	2
4,538	,,	9	8	,,	11	10	49	8	6,100	12	4	0
6,807	,,	11	10	,,	14	0	68	10¼	7,900	15	7	4
9,076	,,	13	8	,,	15	10	87	12¼	9,600	19	7	0
11,345	,,	15	3	,,	17	5	106	14	11,000	22	5	4
13,614	,,	16	8	,,	18	10	124	15⅔	12,400	25	3	6
15,883	,,	18	0	,,	20	2	140	17⅛	13,700	27	17	0
18,152	,,	19	4	,,	21	6	161	19	15,100	30	16	3
20,421	,,	20	5	,,	22	7	180	20⅔	16,500	33	15	0
22,690	,,	21	7	,,	23	9	190	22	17,900	36	13	0

In the first of these tables the first column shows the depth of dressing which the number of gallons, tons, or cubic feet in the corresponding line will give to the land. Thus, a dressing of liquid manure equal to a depth uniformly over the surface of an acre of land of 1 inch will take 22,490 gallons, or 3,645 cubic feet, or 113·4 tons, the diameter of tank being 21 feet 7 inches. The depth of the tank is assumed to be 10 feet from the springing of the invert or bottom brick up to the level of liquid in the tank. In the second table the cost is given of erecting a tank of any given size; the clay required to pack 4 inches thick behind the brickwork; the number of bricks required for the interior, 9 inches thick, with a 4-inch top and a 4-inch bottom, with a man-hole 3½ feet in diameter. The bottom is recommended to be concave, forming a portion of a sphere, the radius of curve of which is equal to the diameter of tank.

73. *The Dung-court, or Covered Dung-house.*—The point has been long disputed whether the dung of a farm should, after collection in the dung-stance, be left exposed or covered up. Many practical men are still of opinion that the dung should be left exposed. The majority of what are called scientific farmers take the opposite view—which we decidedly incline to think the right one—namely, that the dung should be placed under cover. Mr. Thompson, M.P., may be said to be the latest, if not the most able, exponent of this view. In a recent report on Farm Buildings, issued under the auspices of the Yorkshire Agricultural Society, he has the following as to the advantage of covered farm-buildings so far as the manure is concerned:—

> "No farmer will dispute the assertion that *manure is the mainstay of good farming;* and it is equally undeniable that the very best of manure, if exposed long enough to the washing of rain, becomes perfectly useless for the nutrition of plants. But it is difficult to measure the actual loss experienced during a few months of rainy weather, and no calculation can be so satisfactory as actual trial. When first I began to use manure made in a covered yard, it was put on for white turnips in the usual quantity, and they were stimulated by it to an unnaturally rapid growth and excessive size, which were very prejudicial to their keeping qualities, and taught me the lesson, which has since been abundantly confirmed, that manure made under cover is fully one-third stronger than that which has been exposed to the rains of winter in open yards.

Before trial, it might be supposed that manure made under cover would turn out dry and mouldy; but if the quantity of straw used is in reasonable proportion to the number of live stock kept, it will be invariably found that the manure turns out in first-rate condition. The explanation is easy: the most common cause of damage to manure being that the fertilizing salts it contains are washed out by rain as fast as they are formed by the decomposition of the heap, and when these salts are all retained, the moisture will be retained also.

"The only case where the advantage of covering yards is questionable, is on a large sheep-farm, to which little grazing-land is attached. On the Wolds of Yorkshire and Lincolnshire such farms are numerous, and the quantity of straw grown is out of all proportion to the horned stock kept. The few cattle wintered have, therefore, to trample mountains of straw into the semblance of manure, and without the assistance of snow or rain it could not be accomplished. But even in these extreme cases it may be doubted whether wintering more cattle—and thus improving the quality of the home-made tillage—might not be more profitable in the long-run than carting out hundreds of loads of wetted straw and laying out large sums in the purchase of bones, guano, *et hoc genus omne.*

"The third head to be mentioned is the improved economy of management. In covered yards the manure is so much richer in quality, and so free from weak outsides, that there is no necessity for carting it into heaps in order to ferment it down to a uniform mass. It is ready for use when wanted in the field; and being protected from sun, wind, and rain, it is *safe until wanted.* All the expense, therefore, of carting to the heap, unloading at the heap, and turning *in* the heap, is entirely saved.

"The question of cost remains to be considered. This will vary to some extent with the kind of roof adopted. I have ascertained by trial that a substantial roof, covered with ordinary roofing-tiles, may be erected for 5s. per superficial yard of ground roofed over. Each superficial yard of covered space will, on a well-stocked farm, produce annually a cubic yard of well-made manure, worth—if the animals be well fed—at least 5s.; consequently, if manure made under cover be one-third better than that made in the open air, the outlay of every 5s. in roof will produce 1s. 8d. per annum; in other words, will bear interest at the rate of 33 per cent., independently of the improved condition of the stock and the saving in the cartage of manure. The accuracy of this result depends on the soundness of the assumption that manure made under cover is improved in value one-third, which is, of course, an approximation only; and though I am convinced of its truth in my own case, it remains to be proved whether it will hold good when applied generally. But whether, on more extensive trial, the per-centage of improvement be found to be 20 or 30 per cent., there can be no doubt that the improved value is such as to make the subject one of great interest to every farmer, and to warrant the committee in awarding the prizes to plans in which the yards were either covered, or admitted of being so if desired."

74. In concluding the present Essay it will be necessary to point out briefly the principles which regulate the extent of accommodation required on any given farm. The extent of accommodation required will necessarily depend upon such a variety of circumstances that it is impossible to give rules which will be universally applicable. The farmer requiring buildings will be the best judge of what accommodation they should afford, and the architect will do well to consult with him as to all the points involved. There are, as we have stated at the commencement of the present Essay, so many kinds of farming practised in this country, each requiring different arrangements of farm-buildings, and different kinds of apartments therein, that each case must be well studied in its individual peculiarities before the architect can decide as to the extent and kind of accommodation required. The mixed husbandry system presents, we may, however, say, such fixed and determinate features, that it is to this more than to any other system that rules are applicable for the determination of the extent of accommodation required in the farm-buildings applicable to it. Mr. John Ewart, the well-known agricultural engineer, was the first to point out the principles upon which the rules he gives are dependent, and of these we now give a brief *resumé.* Taking the case of a farm cultivated on the five-course system—that is, in which turnips, wheat, or barley, one year's grass, two years' grass, and oats are grown, in about equal areas of ground each, and the extent of which is 300 acres, 60 acres will thus be under turnips; and Mr. Ewart reckons the cultivation of 15 acres of turnips will require the power of two horses; 60 acres will therefore take up 4 pair, or eight horses. The stable for the work-horses of this supposed farm of 300 acres will require to have eight stalls as a minimum, but one or two extra stalls, or a loose box or two, will be necessary. Assuming that half of the produce of the 60 acres of turnips are consumed in the field by sheep, and the other half by stock housed in the steading, one head of stock should be apportioned to one acre of turnips; 30 cattle will thus require to be provided for in one steading, taking up 30 stalls if stall-fed, and 30 boxes if box-fed. In addition to this accommodation here pointed out, cart-shed room will also be required, with space for three carts for every four horses kept; barn and granary, piggery and dairy-cow house will also be required. In addition to what we have stated above, we may advert to the general average number of stock maintained in a dairy-farm, which may be put down at one cow for every three acres of land; the extent of land under turnips to meet the requirements of the number of cows kept, will give that of accommodation for horses required according to Mr. Ewart's calculation as above named. The quantity of turnips to be consumed per cow per annum may be set down at 10 tons—$2\frac{1}{2}$ acres being allowed for summer pasturage and hay; to which should be added 1 ton of wheat straw and $1\frac{1}{2}$ tons of oat straw, to cut with the hay as fodder. These data will be of some value in proportioning the size of Dairy Farm Buildings. The specifications adapted for Farm Buildings will be found in Essay XIII.

NOTICE OF ARCHITECTURAL AND BUILDING CONTRIVANCES

IN THE INTERNATIONAL EXHIBITION OF 1862.

1. The remark may appear strange to some of our readers, that, important as are the departments connected with architecture and construction, they were, nevertheless, represented in the Great Exhibition of 1862 in a manner which—to use the mildest expression—may be said to have been disappointing and unsatisfactory. Not here to be over critical as to the want of proper and philosophical arrangement of the specimens exhibited—a carelessness or oversight, in virtue of which there resulted no small loss of time to those whose duty was (as it was ours) to examine critically all that was exhibited—the disappointment was not so much that the articles were difficult to find, but that, when found, they created dissatisfaction in too many cases, not merely because they were few in number, but because they displayed nothing novel or very valuable in construction or design. But perhaps the most provoking feature of the department of architecture and building was the inequality of representation of its examples; thus, while one department may be said to have been well, if not fully, represented, another, and of equal, if not of greater, importance, was scarcely represented at all. The object of this paper is not to give a mere dry list of exhibited articles, which have long been known, and therefore do not require description, but to present to the reader notices of contrivances which possess features of novelty and practical utility. But these notices will not be very numerous, as, from what we have said above, the articles exhibited of this description were but scantily represented. It is certainly matter of great regret that so splendid an opportunity for showing a complete display ot architectural and building contrivances was in a great measure practically lost. It is needless to point out in detailed form the departments which might have been, and were, indeed, expected to have been fully represented, nor to express very strongly our disappointment that they were scarcely represented at all, for regrets are useless where regrets are vain, and all that is left us is to make such practical use of what was exhibited in that otherwise splendid collection of the triumphs of science and art. To give us all the benefits ot regular arrangement we propose to place our remarks under three heads:—First, House Arrangement and Sanitary Contrivances; second, Miscellaneous; third, the Materials used in Building.

2. *House Arrangement and Sanitary Contrivances.*—The subject of the arrangement and construction of convenient and healthy cottages having attracted the attention of the public for several years, and to a very large and interesting extent, it was fully expected that the International Exhibition building would contain a most complete and systematically arranged series of plans and models illustrative of what has been done in practically solving, or attempting to solve, the problem of getting at once cheap, convenient, and healthy cottages for our labouring population. It was, therefore, with no measured feelings of regret that we found this department, in place of being thus characterized, characterized in fact by the very opposite quality, namely, extreme meagreness. With the exception of one or two plans, so hung above the heads of even the "sons of Anak"—if such ever wandered through the mazes of the departments—that to see what they were was quite out of the question; the only attempt to show what progress we had made in this department of social economics during the last decade was the models exhibited by the "Cottage Improvement Society" of Arundel Street, which exhibition was rendered all the more practically valuable by the oral explanations of points connected with it by the enthusiastic and clever curator of the Society's museum, Mr. Martin. In fig. 1

Fig. 1.

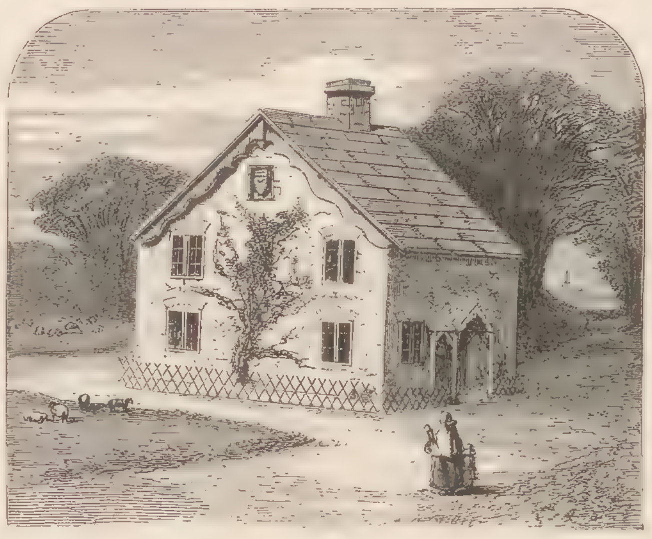
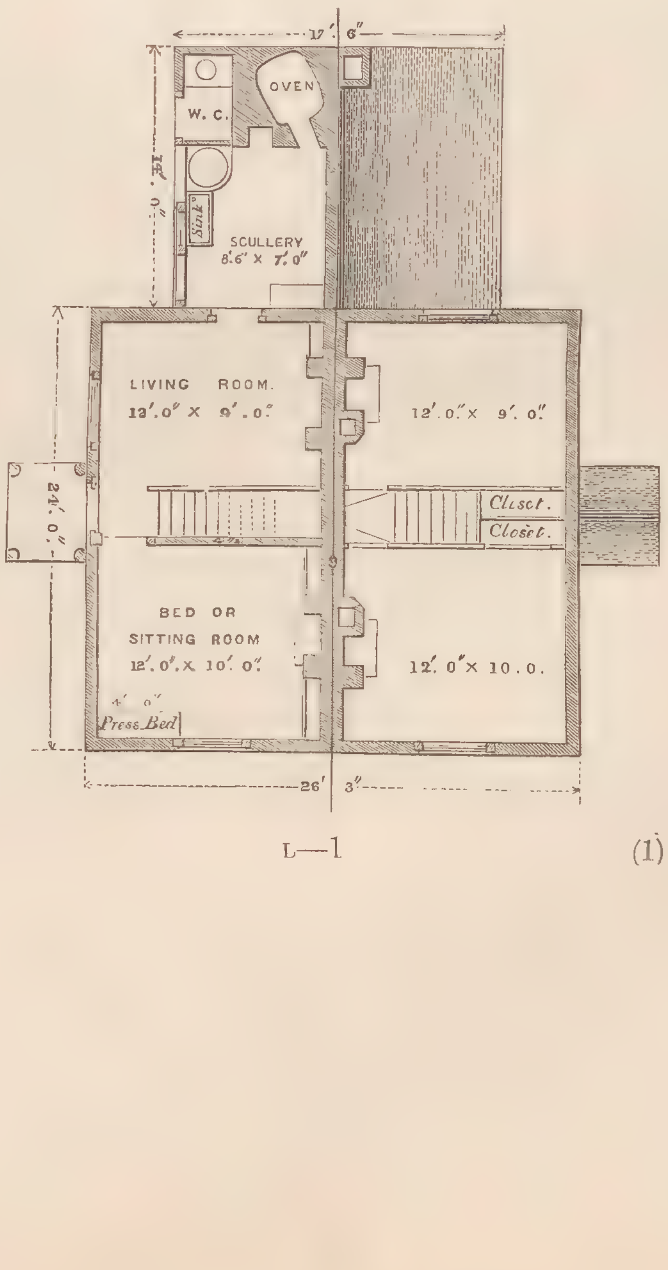


Fig. 2.



we give a perspective drawing of the cottages, of which a model was exhibited; and in fig. 2 half ground and half chamber plan. A pair of such cottages was erected at Hook, near Kingston, for the Rev. T. Pyne, a member of the committee of the society (costing, including fittings and fixtures, £225), as a specimen of what may be done, and as affording a practical test of the applicability of the design. They were inspected and opened by several members of the committee, and were pronounced by all a complete success, both in point of comfort and appearance. Although built in pairs, our readers will perceive that they present the appearance of single cottages, the doors being at the sides. Their internal arrangements are most complete, and comprise a wash-house—containing a pump, sink, copper, fire-place, a fire-clay oven, which will bake a week's consumption of bread with two-pennyworth of fuel, a place for a ton of coals, and dresser, with shelves and drawer, &c.; a spacious living-room with range, oven, and boiler, &c., complete; a large pantry and vegetable store; a parlour (which might, of course, be used as a bed-room), with fire-place and cupboards; and two roomy comfortable bedrooms upstairs, with fire-places and clothes-closets in each. Perhaps the most important fact in connection with the whole matter is that they produce a minimum rent of 4s. per week each, which is amply sufficient to give a fair return on the capital invested in their erection. We are happy to hear that the ensuing spring will doubtless witness the carrying out of this movement to a very great extent. Several of the leading land and building societies regard the matter in a very favourable light, and are making active preparations for experimenting on a large scale.

3. It will not be out of place to notice briefly here the objects carried out by the Cottage Improvement Society:—"'As the home, so the people,' is the proposition on which the whole of the operations of this society are based. Leaving to other agencies the improvement of the moral, intellectual, and religious condition of our working millions, it undertakes the important task of attempting to perfect the conditions under which these other reforms are to be worked out, and it directs its attention at once to the root of a giant evil by endeavouring to provide an answer to the query so often raised as to how the thing is to be done at a remunerative profit. Its object is, in the first place, to make itself a kind of focus or centre of information and experience on the subject, by becoming the medium of communication between, and associating together, parties in various parts of the country, of whom many have for years past devoted considerable attention to the subject; then, after thoroughly digesting and examining the information and experience thus acquired, to place the same before the public in a compendious and practical form by the publication of plans and specifications, exhibition of models, &c.; in short, becoming a complete repository of what is known on the subject. With regard to dwellings for the agricultural classes, we may state at once that the society have placed beyond doubt the fact that suitable cottages, containing a kitchen, wash-house, and three bedrooms, can be well built for the sum of £175 per pair." Those of our readers who feel an interest in this question should pay the Central Cottage Improvement Society's Museum a visit (37 Arundel Street, Strand, W.C.), where the curator will be glad to furnish every information in his power, and where plans and specifications may be obtained, and models inspected.

4. In connection with the sanitary construction of houses, there is, perhaps, no feature so important as having means by which they are *kept free from damp*—one of the most strongly exciting causes of ill health and discomfort in and to their inhabitants. In Essay first in this work we have described the modes usually adopted to prevent damp in houses. We have now to illustrate those contrivances introduced and patented by Mr. John Taylor, architect, 53 Parliament Street, London, and of which the highest architectural authorities have given the most unqualified approval. For the illustrations and the following description we are indebted to the courteous attention of Mr. Taylor.

Mr. Taylor divides the subject of the prevention of damp into three heads—

(1.) How to keep down ascending wet.
(2.) How to keep out drifting wet.
(3.) How to shelter from falling wet.

The greatest evils, in a sanitary sense, are doubtless caused by damp rising up the walls by capillary attraction; wet absorbed as it falls from the heavens was uncomfortable enough, but when it ascended from the lower regions, with its impurities, it was horrible to contemplate the noxious matters rising up with it, and impregnating the walls. In the Isle of Dogs, where the cottages of the poor showed fearfully the effect of damp rising 6 or 7 feet in height, the inhabitants excluded as much air as possible, and so kept up the temperature that the evaporation filled the rooms with foul vapour, causing ague and fever, and the quantity of "pitch pills" consumed, as a cheap specific, would hardly be credited. The Victoria Dock Church, in this locality, has the "damp-proof course" (fig. 3), which so effectually cuts off all damp from the foundations, that any one might see, through the walls, the traffic on the other side; it further gives the advantage of bonding the wall, being equal to sustain 600 feet of brickwork upon the square foot, and at the same time admitting a free circulation of air beneath the floor and joists, thus preventing dry rot. A further useful application of this contrivance is by underpinning with it existing damp houses. As to the defects of tile-paving, it proceeds from the same cause, and it becomes uneven from inequalities in the hardness of the soil beneath any tile. Mr. Taylor's paving (fig. 4) has flanges under each tile, upon which the other rested, thus forming a level platform with a space beneath, through which the air circulates after passing through the damp-proof course. For labourers' cottages these tiles would be cheaper than a wooden floor, because neither timbers nor brickwork beneath were necessary.

Secondly. How to keep out Drifting Wet.—Brick walls are rendered wet by the through mortar joints and the absorbing surface, and these walls, at Southampton and other exposed situations, were covered with slate by way of prevention. Mr. Taylor's facing bricks (fig. 5) are of a highly burnt material, giving vertical bond intercepting the through mortar joints, protecting the surface, and producing a continuous dry area within it; where they are used, the walls are so dry that they could be even papered immediately after their construction.

Thirdly. How to shelter from "Falling Wet."—This object is attained by the tiling, nearly as light as slates, and about half the weight of plain tiling, warmer than slates in winter and cooler in summer, and highly ornamental in effect without additional expense. The capping for garden and fruit-tree walls protects the trees from frost and the upper part of the wall from being saturated and injured by wet.

5. In figs. 3, 4, 5, and 6, we give illustrations of these con-

Fig. 3.

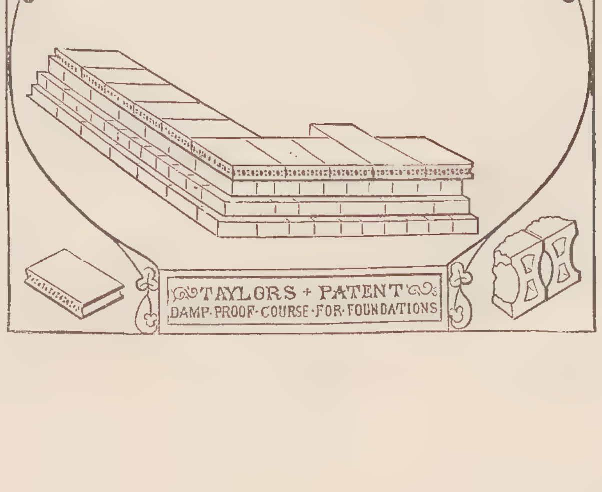


Fig. 4.

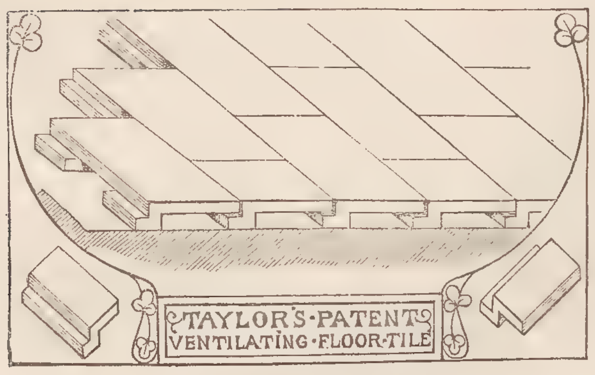


Fig. 5.

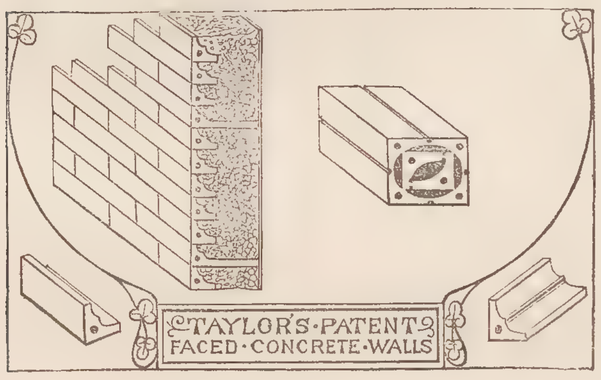
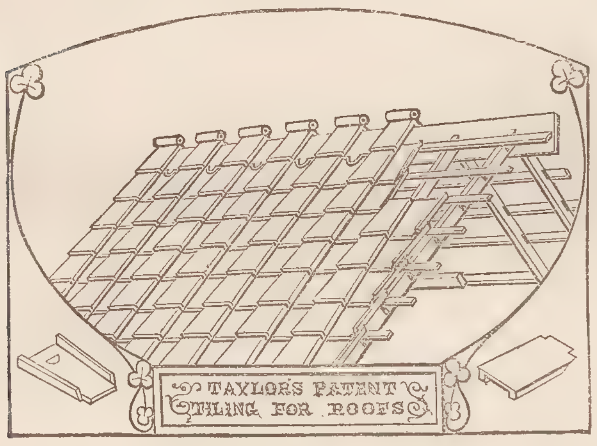


Fig. 6.



trivances. As a dry and cheaply constructed wall is a point of great importance in cottage building, we here give Mr. Taylor's description of faced *concrete* walls. Ordinary brickwork—one brick thick—Mr. Taylor considers totally unfitted for the abode of any human being. "The single brick," he says, "readily absorbs rain and moisture, and the through mortar joint quickly conveys it from the exterior to the interior. Horizontal bond is studied and insisted upon by all careful builders, but, strange to say, vertical bond is never thought of; hence we see the one-brick wall, perhaps, strong enough to bear the intended weight, but not stiff enough to stand even during its erection. Thicker walls are too expensive for a labourer's cottage. In seeking for a substitute, where economy is to be considered, the bulk of the material must be found upon the spot, or in the locality, and nothing is more generally to be found than the necessary materials for concrete.

"We all know that concrete is ordinarily composed of gravel and lime, and is in its proper place when in a trench of a foundation. Being retained therein, and prevented spreading, it will sustain any weight we like to place upon it, but when used in building walls, it is not so retained, and is incapable of enduring cross strains, when the boards, which are, in fact, the moulds in which the cast has been made, are removed. The construction mainly depends upon the adhesive quality of the lime or cement, and when it is no longer retained, cross strain and other causes produce cracks and settlement, and the action of the weather upon the surface soon produces premature decay.

"To understand how my Patent Cottage Walls are constructed, observe the diagram on the right hand in fig. 5, representing a hollow block, which certainly at first appears what no one can understand. It is made by pressing clay through a die. The dark portions represent hollow spaces, through which the heat readily acts throughout the block where desired, during the process of burning in the kiln, and, when standing on end, it occupies the least possible kiln room. It has been partially separated by knives in the die, but holds together firmly enough during burning in the kiln and carriage to the intended building. Just before use, the bricklayer or labourer readily separates it into six bricks specially adapted for the reception of concrete.

"It will be readily seen that in all the several processes of manufacture, six bricks have been produced instead of one. These blocks, or bricks, when used, are laid by the bricklayer on each side of the intended wall, distant from each other the thickness of it, as shown at the left hand of fig. 5. The labourer then lays concrete in the trench thus formed, the vertical pressure upon the flanges counteracts the outward thrust, and thus the concrete is retained as in a trench, the mould wherein the cast was made remaining to protect the wall from damp, and to prevent the decay of the external surfaces of the concrete by the weather.

"Thus, each course is thoroughly constructive, and even first-class houses may be thus built to any reasonable height. In a cottage wall, 9 inches of thickness is sufficient, requiring only one course of blocks externally, with the bonding blocks at intervals, and the use of a moveable board on the inner face during its construction. After this a little rendering inside with lime, or Scott's cement, which is better, finishes the inner face.

"It is calculated that a rod of ordinary brickwork requires 4,352 bricks, which (at, say, 32s. per 1,000) costs £7. One rod of the patent walling requires 1,450 of my bricks, which (at 25s. per 1,000), for labourers' cottages, only costs £1 16s. 3d.; add to this the cubical contents of the concrete, $9\frac{2}{3}$ yards, at 16s. 8d. (calculating gravel at 2s. per yard and lime at 10s.), £1 12s. 8d. together; £3 8s. 11d. the rod of 14-inch work, as against £7 the rod of brickwork.

"Now, as to the weight:—the 4,352 bricks weigh 9 tons 14 cwt.; the 1,450 of my bricks weigh 1 ton 9 cwt. We thus see that these blocks can be sent in a railway truck, or otherwise, long distances, where we could never hope to send bricks. When my blocks for facing ordinary brick-work are used, they cause continuous hollow air spaces to be left within the wall, and a great saving in bricks results. Vertical bond is obtained, and the yielding mortar joints are strengthened." In this department Mr. Jenning, the well-known maker of so many sanitary contrivances, exhibited a *glazed brick for foundation courses for the prevention of damp.* A course of this glazed brick is used in place of the usual layer of slate or cement, and there is no doubt of its efficacy up to a certain point,—which point, we candidly confess, we believe to be below that of the hollow damp-proof course of Mr. Taylor, already described. We are inclined to recommend an internal course, or lining of walls of rooms, with the glazed brick, as a means of rendering the rooms dry.

6. *Drainage Contrivances.*—This subject having been pretty fully discussed in another Essay in this work, and in which are embodied descriptions of the most recent contrivances, most—if not all—of which were exhibited, we have here comparatively little to give in connection with this department. A few remarks will not be out of place, however, on the subject of "dry" as against "water" *closets.* Several of these dry water-closets were exhibited, and although it does seem at first sight a retrogression in sanitary science to introduce methods by which human excreta are retained in or near dwellings in place of getting rid of it at once and sending it to its place of final deposit—the river or the sea—through the agency of water, still there are some points of importance involved in the principle which should not be overlooked. In towns where the supply of water is at once plentiful and con-

stant, the mode generally adopted seems by far the best, as it is the most prompt in its action. But so long as such marked attention is directed to the importance of saving the excreta of our population to be used for manure, so long will the minds of some amongst us be occupied with plans by which these excreta will be kept in as complete a condition as possible—that is, not mixed with and greatly lowered in value because lowered in manurial strength—by the large accession of water which is occasioned by our ordinary water-closet system. Again, it should be remembered that in rural districts water in sufficient quantity is not easily obtained without special and expensive apparatus being secured to keep up the supply, hence another reason why the introduction of "dry closets" is advocated by some. The main feature in all dry closets is the employment of a deodorizing material in the body of the box. We know of no material so completely efficient as dried earth or clay, as proposed, and most successfully introduced, by the Rev. Mr. Moule, Dorset. It was with regret that the apparatus invented by Mr. Moule, by which the dried earth is used, was not exhibited—at all events, if exhibited, we could not find it. Mr. Smith of Glasgow exhibited a form of dry closet, arranged, we believe, on the principle patented by Dr. Lloyd, and in which ashes, or lime and ashes, are used as the deodorizing material. We can speak from experience as to the value of coal ashes as an excellent deodorizer of fæcal matters. The following gives a description of Dr. Lloyd's apparatus, and of some of the points on which he bases the value of his system:—"The pan of the closet is divided into two chambers by a vertical or curved partition, so that the urine falls into the front compartment and the dung into the back one. By a mechanical contrivance, a broad flat valve closes over the pan, and causes a shower of fine pounded ashes to fall upon the evacuations, or of lime, or of lime and ashes. The ashes, or lime, or lime and ashes, are intended to absorb all moisture, and to dry the remaining solids in the evacuations. The average weight of the solid matters in the urine and dung of each person per day is about 5 ounces, and the fæces or dung are reduced in weight to 1, 1½, or 2 ounces daily by the action of ashes, lime, or lime and ashes, or burnt clay, so that all water is separated from evacuations in this way. That urine contains twice as much solid matter as dung, and that the object of the partition in the pan is to prevent the dung and urine mixing, and so prevent fermentation and putrefaction. That the refuse of fires is a perfect and effectual remedy so long as the ashes are newly burnt, and fresh, and dry; that they are of little value if moistened by the air or otherwise; that lime is an invaluable aid to ashes to make the process more rapid and complete; and that one part of lime to two of ashes will be found ample. But where ashes are freshly burnt and abundant, they will suffice alone. But salt may be used, in the occasional absence of the other substances, as an antiseptic. That ashes alone absorb nearly their own weight of liquid, and that farm-yard manure, in its average state, contains about nine-tenths of water. If ashes are wet they cannot absorb rapidly; lime is used mainly to dry them, though it has a most powerful deodorizing action of its own upon fresh evacuations, quite different to that when they are putrid. That there is no loss of the real solid chemical and valuable properties of the evacuations or slops from kitchens or wash-houses, and that the carbonic agents simply lock them up for a time until laid upon the field or exposed to air, or water, or rain. That the scheme prevents the escape of bad smells; that all moisture is absorbed or evaporated; that the chemical property in the dung and urine is retained and dried into powder; and that it may be removed as conveniently as so much sand, dust, or ashes." In the department now under consideration several forms of apparatus adapted to water-closets, drain-pipes, traps, &c., were exhibited; several of these were distinguished by no feature of novelty, being, in fact, those forms with which all engaged in the constructive arts have for long been familiar. Mr. Underhay's valve for a water-closet was distinguished by some novelty; attached to the pan is a small bellows, acted on by the handle; as this is lifted the bellows become filled with air, which, as the handle descends, passes slowly out, and at the same time acts in conjunction with a regular flow of water. Great objection is sometimes made to the waste of water occasioned by the use of the ordinary apparatus of water-closets. Mr. Chantrell exhibited a form intended to obviate this. Near the pan a vessel is placed which holds just sufficient water to cleanse the pan effectually, and no more. This vessel is supplied from the cistern, or other source of supply above, and valves are so arranged that when the handle is lifted to allow the water to pass from the small vessel, the valve admitting the water to it from the cistern above is closed. When the small vessel is emptied, and the handle of the closet descends, the valve leading from the vessel to the pan is closed, while that from the cistern is opened, thus admitting a fresh supply to the vessel in readiness for use at another time.

7. In the department of *filters*, Mr. Spencer of Liverpool exhibits a thoroughly scientific and efficient novelty. The material he employs is an "artificial magnetic oxide of iron," which is said to possess great powers, removing all impurities, even from water impregnated with peaty or mossy matter. The great practical difficulty in the use of filters is the cleansing of the material of which they are composed. But all difficulty on this score is obviated by Mr. Spencer's material, which is said to be self-cleansing, or rather—to put the matter properly—its action is said to be perpetual, inasmuch as while retaining its own supply, it draws from the air its oxygen, which is made to combine with the organic matter in the water. The carbon, or solid charcoal filters, were also exhibited; these are very effective, and are furnished in almost every variety of form.

8. *Heating Apparatus.*—Little novelty was shown in this department—perhaps the chief novelty was in an apparatus of M. Zunaia of St. Petersburg, which consisted of a series of earthenware pipes attached to a stove—an obvious modification of the "porcelain stove" much used in Russia and other parts of the Continent. Mr. Woodcock exhibited his form of apparatus and fire-grate, illustrations of which the reader will find in Essay Fifth of this work. Before concluding our brief notice of this department we will do our readers a service by illustrating the form of grate invented by Mr. Taylor, whose building contrivances we have already in the present Essay described. In fig. 7 we give a front view of this smoke-consuming and ventilating grate, and in fig. 8 a section with front

Fig. 7.

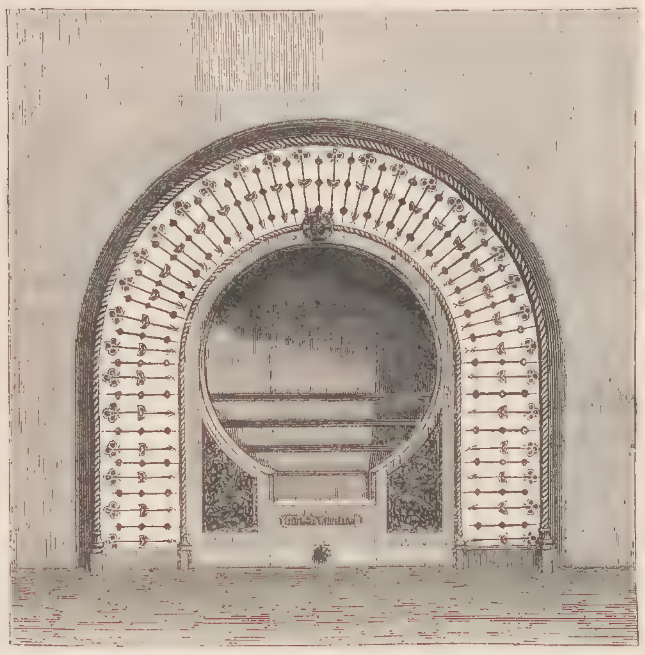
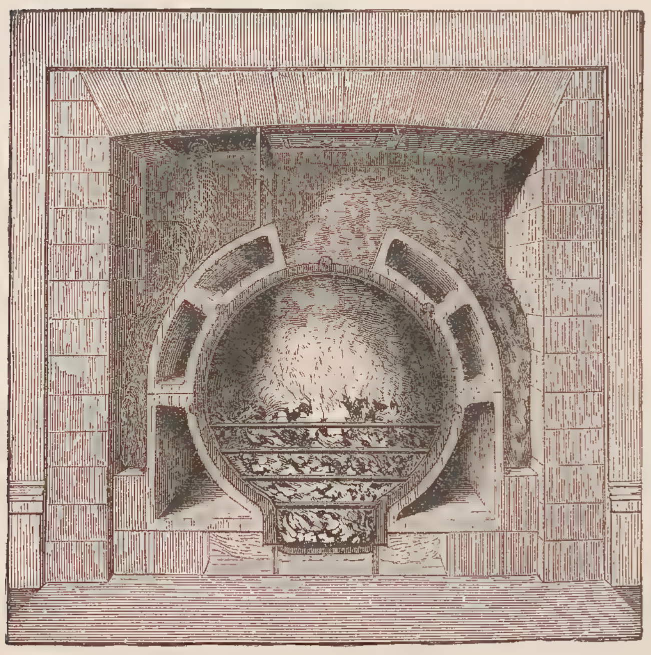


Fig. 8.



removed; the peculiar features are thus described by Mr. Taylor:—

> "When the register is closed, the smoke, having ascended from the fuel and become mixed with atmospheric air, descends, and passes through the hottest part of the fire, where the carbon or soot in the smoke is consumed as fuel. The heat which would have rushed up the chimney, calculated at 75 per cent., passes down and around the hollow fire lumps of which the grate is formed, and the external air, with which these communicate, enters the apartment in a large body, moderately warmed, not heated. The apartment is supplied with moderately warmed instead of cold air, from door or window, and thus thorough ventilation is effected. The cold air cannot rush up the chimney; the flue is therefore rendered a powerful extracting shaft for ventilation, and a highly rarefied, and consequently effectual, passage for the products of combustion, thus obviating another fruitful source of smoky chimneys. Should the warmth be too great, the register can be opened, and the action of an ordinary grate will take place. In addition to these advantages, the fire is always under perfect control, and may at all times be brought to any degree of brightness. Its combustion of fuel is so perfect, that what remains in the ash-drawer, after the day's consumption, if proper attention has been paid, might be taken away in the palm of the hand. The occupation of the sweep will be nearly dispensed with."

9. *Ventilating Apparatus.*—The principal forms of apparatus exhibited the reader will find illustrated in Essay Fifth in this work, such as those of Cooke, M'Kinnel, Muir, &c., &c., We are therefore spared the necessity here to enter further into the subject, deeming it only necessary to draw the attention of the reader to the remarks made by the writer of the report (in the Official Report of the Great Exhibition, issued by the Society of Arts) on the subject of the forms of apparatus introduced by M'Kinnel, Watson, Muir, &c.:—

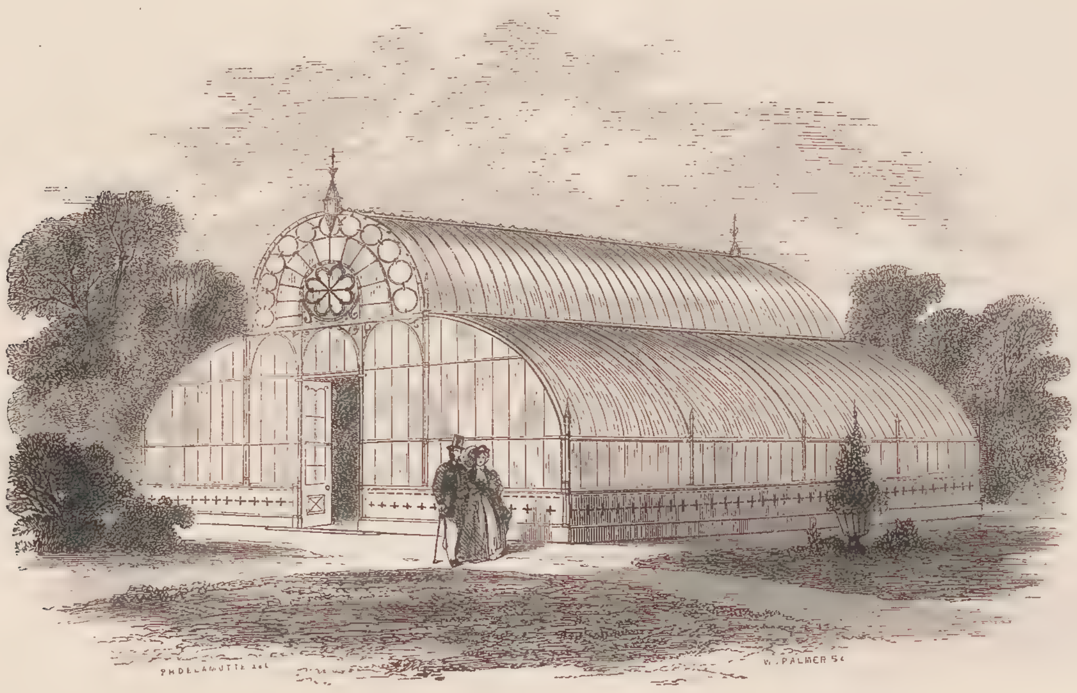
> "Qualified commendation has been bestowed on three forms of ventilating arrangements, known as those of the patentees, Messrs. Watson, M'Kinnel, and Muir. These are essentially only a union in one tube of channels of outlet and of inlet, and any ventilating openings are precious compared with none; but the following defects may be noted in them:—They have not self-acting valves to regulate the currents in the air-channels by preventing the constant fluctuations and inversions of current from the unsteady influences acting. They do not sufficiently employ Nature's greatest ventilating force, that of the wind, by means of blowing-cowl, or otherwise, to insure the motion of the various currents. They have no valved opening into the chimney-flue near the ceiling of the room, producing the useful effects which follow when there is the essential command of the chimney throat by the fit register, or valve * * * * by which the chimney draught can be powerfully increased and rendered efficient to produce, where desired, a perfect local ventilation, as of gas-burners and other lights, sick beds, or any limited sources of impurity. The particulars above noted can be judged of by common experience and reflection, and they regard the comfort of every house. There are other means bearing on ventilating and warming, of which the nature is explained in the work above referred to, which are not quite so simple, and which regard rather whole buildings than single rooms. Only one of these shall be here noticed. Dr. Arnott discovered before publishing his 'Elements of Physics,' and as described in that work, that any given quantity of hot water (it may be boiling) and an equal quantity of cold water (it may be freezing) can be caused to run past each other in separate channels, and shall not thereby become a double quantity, having a middle temperature, but the boiling water shall immediately be cooled to very near the freezing point, and the freezing water shall be heated to near the boiling point; in other words, the two shall wholly exchange temperatures. He found also that the same interchange can be effected between quantities of air, so that foul hot air issuing from a breathing crowd can be made to give pure warmth to an equal quantity of fresh air entering. Dr. Arnott showed this heat-transferer to Dr. Sutherland and Dr. Angus Smith while they were engaged in the jury work of the present Exhibition, and to various other jury members. The apparatus, or heat-transferer, is very simple, and little costly. Three persons have taken patents for imperfect approximations to it within the last two years, and are manufacturing what they call refrigerators for the use of breweries. Examples are to be seen in the present Exhibition."

The following remarks from the same Report will show the present position of sanitary contrivances, and what yet has to be done in this department:—

> "Sanitary reforms, such as they appear at the Exhibition, show that men are striving after materials with which to act, and also after forms in which to embody the well-known old ideas. New ideas of a purely sanitary kind we have absolutely none before us, although since 1851 the subject has grown widely. We know more of the condition of the air, we know more of the necessity of ventilation, and more of its difficulty, but the progress of our knowledge has not been seen in the Exhibition. Thus far we see a defect in it; the whole circle of human invention has not been exposed to view, and room is made for improvement in a future Exhibition. Although we have not shown all that has been done, we must not forget that much is still undone; we have not learnt the best mode of ventilation, nor solved the sewage problem. We have not decided on the best way of rendering all the food sold to the poor and to the rich perfectly free from noxious adulterations. We have not liberated ourselves from the fear of being poisoned by arsenic on the walls; nor, if this be poisonous when used on paper, have we decided if it be wise to live with other noxious metals around us, ready to fall in powdery oxides as dust into our lungs. We have not solved the problem of the best pipe for supplying water, which, with the purest supply, shall still give us no lead or injurious metal, although one patent, which has gone far towards this, exists, but little used and not exhibited. We have not learnt how to live in great communities, enjoying the advantage of social intercourse, without the disadvantages of many accumulated evils, in which we breathe with dislike. We have not solved the problem of smoke, of sulphur, and arsenic, in our towns, our manufactories, and especially our mines and metal works. We cannot warm and ventilate a small room so as to make it healthy and comfortable, and we cannot build a house suited to the wants and wages of our population. These are a few of the problems before us on which the nation's eyes have been more distinctly fixed, and the response in the Exhibition has not been so great as the intellect of the country led us naturally to expect."

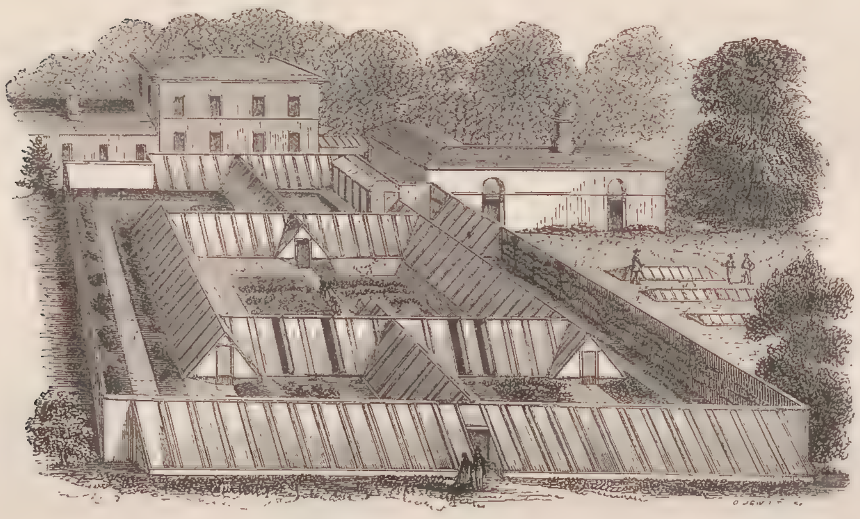
10. *Miscellaneous Articles Exhibited.*—In the annexe, which contained the agricultural and horticultural implements, a number of models of greenhouses and conservatories were exhibited. Some of the designs of conservatories were very good, as, for instance, that exhibited by Weekes. In the Essay on Garden Structures we have explained the principle of construction patented by Mr. Dennis of Chelmsford. Fig. 9 illustrates the design for an ornamental conservatory on this principle, as exhibited full size in the grounds of the annexe. In Essay Fifth we have also described the system of hot-house construction patented by Sir Joseph Paxton; fig. 10 will, in addition to the drawings we have already given, illustrate the very complete and yet simple manner in which this system can be applied to general purposes. Of the department of machines connected with building construction, we have only space to allude briefly to the wood-working machinery. The

Fig. 9.



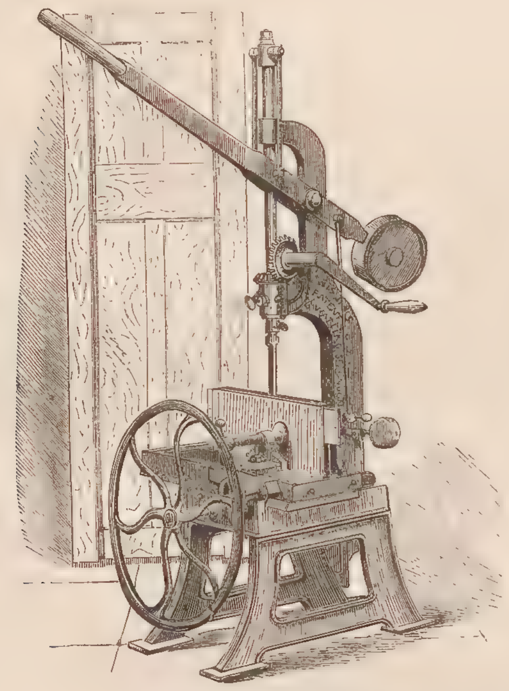
Dennis's (Chelmsford, Essex) Conservatory.

Fig. 10.



exhibitors of the United Kingdom to whom medals were awarded were Morgan & Co., Paisley; Powis, James & Co., Blackfriars Road, London; Robinson & Son, Rochdale; Worssam & Co., King's Road, Chelsea; and Greenwood & Batley, Leeds. The *sawing machines* exhibited may be classed under three heads—First, the reciprocating, with rectilineal blades of a determinate length, fixed to a frame moving up and down vertically; second, rectilineal blades, but continuous or endless, passed round two pulleys; and third, the circular. Powis, James and Co., exhibited a "combined timber and deal frame," capable of cutting up round or square logs up to two feet in diameter. It is made to work from above, so that no excavations are required. Worssam & Co. exhibited a portable deal-cutting frame, adapted to cut twenty thin boards out of two deals 14 inches by 4 inches in section. In this machine the old spring used to balance the weight of the saw-frame is dispensed with, and an air cylinder is substituted with great advantage. The machine makes a 9-inch stroke and 250 double strokes per minute. The ribbon, or endless saw, although recently and largely introduced, is by no means a new invention. It was described by Newbury in 1808; Tourode used this form of saw so early as 1815, yet it appears to have been altogether overlooked in after years, for in the 1851 Exhibition no example of it was shown. Perin in 1855 exhibited in the Paris Exposition a machine in which the advantages of this mode of sawing were fully illustrated, and since that period it has been widely introduced. The great difficulty was to make a perfect joint of the two ends of the band-saw, and Perin was the first to overcome it. Greenwood & Batley of Leeds exhibited a saw of this class adapted to curvilinear-formed pieces. This machine is very highly spoken of by competent judges; the table is fixed, and the pulleys are carried by framing mounted upon a pair of trunnions, by means of which any required degree of oscillation or variation from the perpendicular can be adjusted. In *planing machines*, Powis, James & Co. exhibited a combined planing and moulding machine, provided with a revolving cutter-head to take off the external dirt. The edges are planed by vertical revolving cutters, which are adjustable to any width of plank; the horizontal cutters are also adjustable, and the machine is capable of taking in planks up to 12 by 6 inches in section. In *mortising machines* the aim of makers is to produce a square-ended mortise. Where boring tools are alone used—the ends of the mortise being left rounded—they must be squared by hand or by the action of another arrangement of mechanism. Worssam exhibited a machine in which the mortises are left square-ended. The cutting part consists of a hollow square, the lower edges of which are chisel-shaped; in the interior of this a revolving screw-augur works; this augur is placed a little in advance of the square, which leaves the mortise square-ended. For hard woods this tool is particularly valuable, as the chips made, being of short fibre, easily clear themselves; in soft woods, the fibres being longer, there is a greater difficulty in getting the tool cleaned. This remark, indeed, applies to most of the mortising machines introduced, and the evil has been attempted to be removed in a variety of ways. *Tenoning machines:* Powis, James & Co. exhibited a machine capable of tenoning large timbers, while Worssam & Co. exhibited one suitable for small joiners' work; it is provided with an adjustment capable of cutting tenons with unequal shoulders. The *moulding machine* exhibited by Robinson & Son of Rochdale is very highly spoken of as combining many good contrivances, which produce mouldings of fine contour and smooth surfaces. *Compound machines* are now being rapidly introduced, and are highly esteemed, especially by small makers, as several operations can be effected by them, with comparatively simple adjustments. Kinder's shaping-machine, exhibited by Greenwood and Batley, attracted great attention from the endless variety of work it is capable of producing. The machine exhibited by Worssam & Co., and called by them the "General Joiner," is capable of sawing, grooving, tonguing, rebating, tenoning, moulding, boring, cross-cutting, and squaring off. In fig. 11 we illustrate the combined mortising, tenoning, and boring machine, exhibited by Powis, James & Co. The following remarks of Mr. Whitworth, the eminent mechanician, on the subject of a standard of sizes for house fittings, will appropriately conclude this section:—"I think no estimate can be formed of our national loss from the over multiplication of sizes. * * * This question is also well worthy the attention of our architects and builders. Suppose, for instance, that the principal windows and doors of our houses were made only of three or four different sizes. Then we should have a manufactory start up for making doors, without reference to any particular house or builder. They would be kept in stock, and made with the best machinery and contrivances for that particular branch; consequently we should have better doors and windows at the least possible cost.' Fig. 11 illustrates a combined mortising, tenoning, and boring machine, exhibited by Messrs. Powis, James & Co. Of models, or examples of novelties in building construction, there were few or none; certainly it may be said, that the building itself illustrated not a few points worthy of the attention of the architect or builder. To some of these we have drawn the attention of our readers in the Essay on Timber Construction; we deem it, however, right to add to these a single note on the principle adopted in the construction of the picture gallery; a principle, the value of which has been admitted by all, even of the most hostile critics of the building itself. The principle is that of top lighting, so successfully realized in the gallery built for the Sheepshanks collection. The principle is equally applicable to private as to public galleries, to large as well as small rooms. It requires that the width and the height of the room should be the same, and the space for the skylight half the width. Thus, if the width of the floor be twenty feet, the height should be twenty feet, and the skylight ten feet in the centre. A picture properly hung in such a room cannot have any glitter, and must be perfectly seen. (See fig. 12.)

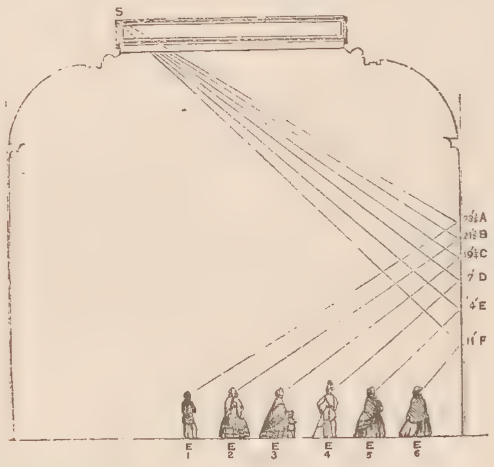
Fig. 11.



Powis, James & Co.'s combined Mortising, Tenoning, and Boring Machine.

11. *Materials.*—Having devoted a special section to this department, we have but little to note here on it. The specimens exhibited were numerous and valuable, but it is obvious that it would serve but little practical purpose to give a dry list of the names of these specimens, and of the parties by whom they were exhibited. The various materials shown throughout the building—in any thing, we regret to say, but a well-classified and managed system, were classed by the official reporter into three divisions:—first, "natural building materials;" second, "artificial building materials;" and third, "general building materials." Introductory to the notice of the specimens exhibited in these divisions, the reporter gives the following remarks, (*Natural Building Materials*):—

Fig. 12.



> "The collections of building materials exhibited by every country, not only demonstrate great capability of producing varieties of valuable natural products, but also evince a strong desire to develop the resources of the building art in a very remarkable manner. These specimens appear to have been selected with considerable judgment, and they illustrate almost every kind of stone which can be employed in any department for constructive purposes; and they are generally shown both in their rough and their worked states, in order to exhibit their respective qualities, and the purposes to which they may be most advantageously applied. It was not always possible to ascertain the price at which these articles could be produced, and which forms a most important element in the building art; nevertheless enough has been done to prove that these materials can be obtained, and used with advantage wherever the cost of transport is brought within ordinary limits. The existence of many of these classes of materials had in some cases been previously unknown, but their localities being now pointed out, they will soon be rendered useful wherever a demand exists."

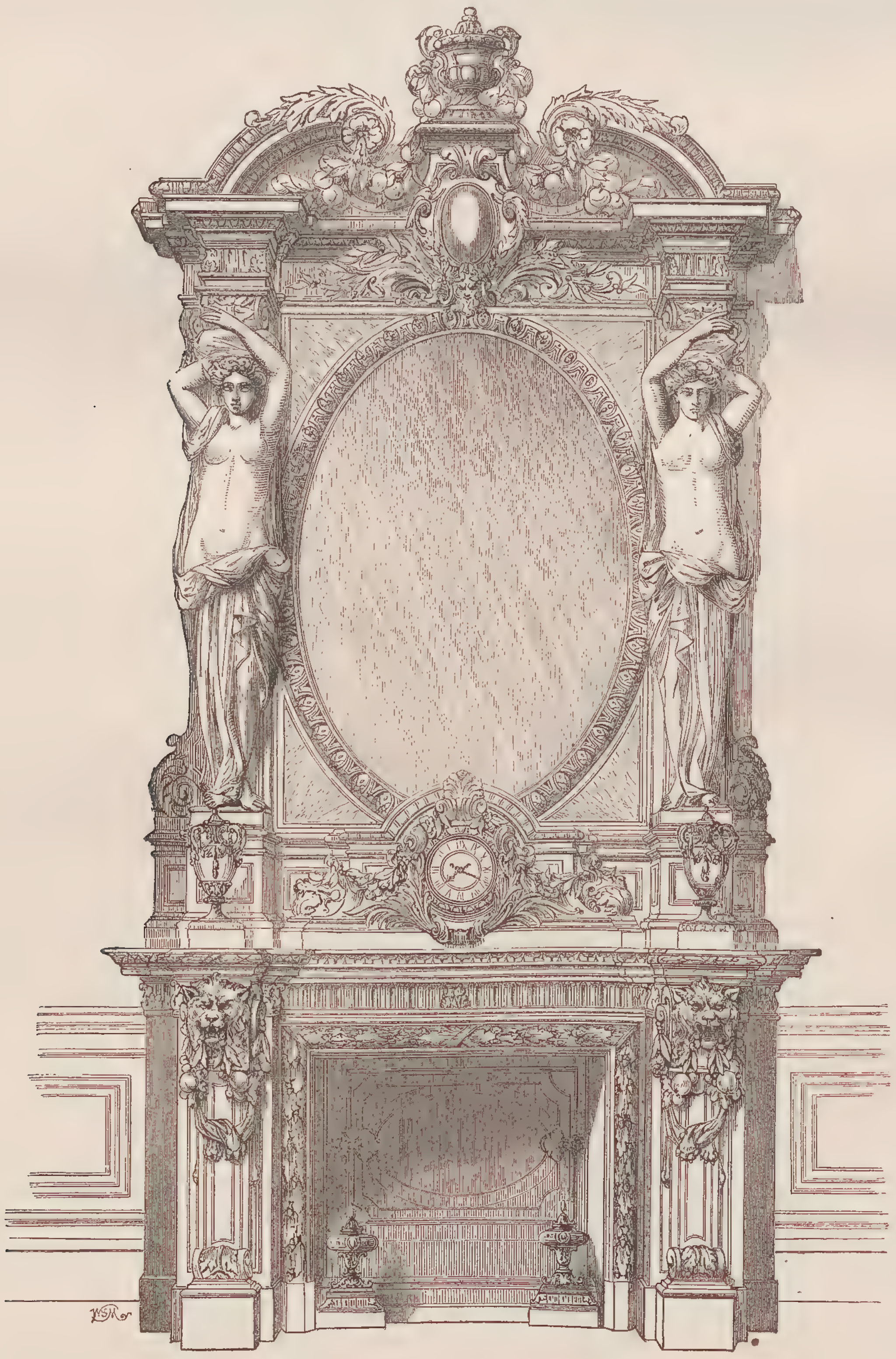
From the specimens of natural building materials, exhibited or obtainable in any quantity from our British Colonies, from Victoria, Queensland, Tasmania, Malta, France, Italy, Prussia, Sweden, and Bavaria, "it will be evident," says the reporter, "that very valuable natural materials have been found, and exhibited from a variety of places, where their existence was scarcely anticipated; many are susceptible of considerable development, and they will contribute essentially to the advancement of the building art, both as regards economy and solidity of construction, and all that is now required is facility and economy of transport." Of the artificial building materials we have the following:—

> "This division, including cements and artificial building materials, béton or concrete blocks, bricks, tiles, earthen pipes, &c., would demand a very lengthened notice if the very various qualities and applications of the several kinds were to be separately treated of. The limits of this report will only permit the several varieties being mentioned as in other divisions, almost entirely restricting notice to those to whom medals or honourable mention have been awarded.
>
> "The engineer or architect can generally, from practice, judge with tolerable accuracy of the applicability and durability of building stone, because having seen it in the quarry and in buildings where it has borne the test of ages, it may be inferred that if applied under similar circumstances it will be equally durable; but this is not the case with artificial materials, of which the experience must of necessity be limited; therefore, all that can be done is to judge of them from their constituent particles, compare them with the natural materials of which they profess to be the prototype, carefully investigate the modes of preparation, and form an opinion from the results actually obtained. Still with even this information successful results are not certain, because so many ele-

> ments enter into the composition of artificial stones, and so much must depend on the process of manufacture, and on the subsequent manipulation, that nothing but actual experience of any artificial substance, after a number of years' exposure, under every variety of circumstances, can justify a decided opinion being pronounced.
>
> "Many artificial stones, which at first sight appear admirably adapted for the purpose, are found, when exposed to this unerring test, to be utterly wanting in durability. No artificial stone can therefore be considered durable, as compared with natural stone, until it has undergone the test of long experience, although in many cases béton, or concrete blocks, have been and are now employed with advantage, where natural stone cannot be obtained at a reasonable cost. * * * With regard to *artificial cements,* there have been exhibited an endless variety from every country. These, like the artificial stones, still require the test of experience before they can be pronounced as fit to take the place of natural cements, although they may be applied with considerable advantage, where natural cements cannot be obtained at a reasonable cost. One of the most remarkable of these artificial cements is what is termed the 'Portland cement,' which has been proved to possess excellent hydraulic qualities, and it is now so much used that the name has been generally applied throughout the continent to cements possessing similar qualities."

In this class of artificial building materials, Ransome exhibited a block of his patent stone, of which the Jury reported very favourably, and to which they awarded a medal. Special notice was also given by them, and the like honorary distinction paid to the system of forming concrete blocks introduced by Coignet, Brothers & Co. of Paris. To M. Kuhlmann of Paris, whose researches into the best methods of indurating stone by the application of silicate of potash, the Jury awarded a medal. In the department of cements a medal was awarded to Capt. H. Y. D. Scott, for discovering a good and cheap cement, which is remarkably well manufactured by Messrs. Lee, Son, & Smith, to whom honourable mention is awarded for the process of manufacture of this article, the excellence of which the Jury were enabled to judge of in the construction of the buildings at the South Kensington Museum, where some instances of great strength were shown; also to Messrs. White, Brothers, a medal for the general excellence and extensive production of their Portland cement, which, as in the previous case, the Jury were enabled to examine in the general construction of the building of the Exhibition, and more especially in the bases of the columns supporting the domes, and in the basin of the great majolica fountain, where its powers of hardening and of impermeability were satisfactorily tested by watching the progress of the construction, and the subsequent introduction of the water.

Fig. 13.



Jackson and Sons' Caston Pierre Chimney Piece.

ON THE

APPLICATION OF ISOMETRICAL PROJECTION

TO

THE DELINEATION OF ARCHITECTURAL SUBJECTS.

1. The following paragraphs and diagrams are intended to convey to the architectural student uninitiated in the practice of projection, a general outline of that kind which is known as *isometrical*, and which we conceive likely to be of utility in the delineation of architectural subjects. Of its adaptability to the preparation of a graphic representation of the interior arrangement of a house—so as to serve to the client as a species of model by which he will be able at once to understand the nature of the accommodation the architect proposes to give him—the reader will find in Essay Thirteenth of this work some corroborative and suggestive remarks.

2. It is unnecessary here to go deeply into the general subject of *projection*, nor will space permit of our doing so; it will be essential, however, to glance briefly at the principles upon which isometrical projection is founded. Every tyro in architecture is acquainted with the mode of delineating objects in *plan*, *elevation*, and *section*, and which, so long as they are drawn upon one plane surface, are, in fact, correct representations of the subjects delineated, and give a true notion of all sizes, distances, and relative positions, of one part to another. An immense advantage this species of delineation in a plane possesses, is that all measurements of every part, and in every direction, can be taken with the most rigid accuracy from *one scale*. But while showing correctly all parts in one plane, this species of delineation is not applicable to cases where it is desired to show the relative position of lines which are in one plane — as horizontal — have to lines which are in another plane — as vertical. When this is desiderated, another drawing, showing the subject delineated in another plane, is required; and it is only by the careful collation of several drawings, plans, and elevations, that an idea can be obtained of the relation which the vertical have with the horizontal lines. This can very easily be done by those who are conversant with the preparation of what are known under the generic name of *plans;* but it is not so easily done; in fact, in many cases it is not done at all by those who have not the advantage of this experience. And it is just because that, as a rule, architects, in the ready facility with which they can "read off plans," forget that their clients cannot, that so much disappointment is found to exist where proprietors of houses have had no true conception of what their structures were to contain in the way of accommodation, however conscientiously and earnestly their architects may have pointed out the peculiarities of the plan. In the case of large and important structures, where everything is left to the architect, and he must stand or fall according to the ability displayed in the design, it does not so much matter whether his employer has or has not a correct notion of all its details; but in the case of domestic structures—which are made as a primary object to live in, not to look at—we contend that it is worth the while of the architect to indoctrinate his client with a correct idea of the accommodation he proposes to give him in the house he wishes to erect. We believe that this can be best and easiest done by isometrical drawings, as hereafter to be explained.

3. The impossibility, therefore, of showing the relative position of vertical and horizontal lines in common plans, has necessitated the delineation of subjects in what is called *perspective*, in which the object is shown on paper as it appears, or would appear, when viewed from a distance. In this the lines converge to points, so that the parts nearest the eye are the largest, while the most distant are the smallest; while the colour of the nearest parts is strongest, that of the distant weakest and faint. But however useful—and in many instances indispensable—this species of delineation is to the architect, it possesses two great disadvantages: first, it is tedious to execute accurately, and intricate to the uninitiated; and second, the distortion, or apparent distortion, is such that no measurements can be taken from such drawings from any scale. Many modes of projection have been proposed, but by none is the combination possible of horizontal with vertical lines, all of which can be *measured from the same scale*, except by that method of viewing a *cube* from an infinite distance, and in the direction of its diagonal produced. Professor Farish of Cambridge was the first—in an able paper in the first volume of the Philosophical Transactions of that University—to point out the advantages of this mode of projection, which he proposed to call—and which denomination is in fact universally adopted—*isometrical* drawing, from two Greek words, signifying *equal measurements.*

4. A cube is defined as one of the solid bodies, "having six equal square sides, twelve boundary lines of equal length, eight corners, and six diagonal planes." The following is a simple

Fig. 1.

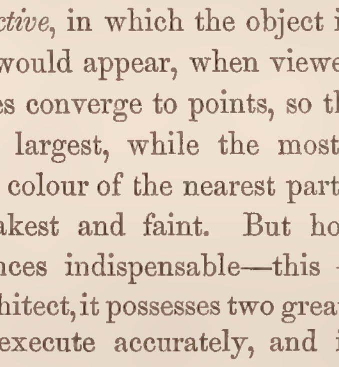
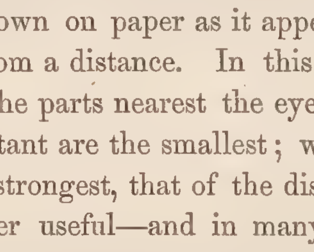


Fig. 2.



mode of forming a cube within a given circle:—Let *a*, fig. 1, be the given circle; through the centre *a* draw a line or diameter *b a c*, dividing the circle into exactly equal and similar parts. Next divide the right hand semi-circle *c b d e* into three equal parts in the points *d* and *e*, and the left hand semi-circle *c g f b* similarly in the points *g* and *f*. Next join the points *g c*, *c d*, *d e*, *e b*, *b f*, *f g*, and from the centre *a* draw lines to *g* and *d*; *g c*, *d e*, *b f*, is the cube required. Fig. 2 shows the cube shaded.

5. But while this is a ready mode of delineating a cube within any given circle, it must be remembered that this does not enable an exactly correct isometrical projection of a cube of which the side is given. Thus: suppose the line *a b*, fig. 2, to represent the length of one of the sides of a cube, of which it was desired to have an isometrical projection; if this projection was made, as, say, in fig. 1, the length of the corresponding side, *g c*, fig. 1, would not be the same as *a b*, but less. A line, therefore, when projected isometrically, is less than the line from which it is projected, and this in the proportion of 9 to 11; a line, then, 11 inches long, when projected isometrically, will be only 9 inches long. A method is therefore required by which we can project or draw a cube isometrically, of which the side is given. The following is the method given by Mr. Jopling, in his work on "Isometrical Perspective," published by Messrs. Walton & Maberly, London. Let *a b*, fig. 3, be the length of one of the four boundary lines of a cube, of which *a b c d* is the side. Draw the diagonals *a b c d*, and from *b* a line *b e*, cutting the diagonal *c a*, so as to make the angle *d b e* equal to 30°. Then from any point as *a*, fig. 4, with radius equal to the distance *b e*, fig. 3, describe a circle, and divide this with the same distance into six equal parts in the points *c d e f* and *g*, which, being joined as in fig. 1, will form a cube, of which the side *g f* will be an isometrical projection of *a b*, fig. 3. To form the angle *d b e* of 30°, let *a c b d*, fig. 5, be the diagonals of the square *a b c d*, fig. 3; then from point *a*, corresponding to point *b*, fig. 3, with a radius of 60°, taken from a scale of chords, describe the arc *e f*; then from the same scale of chords take the distance 30°, and set this off from the point *e* to the point *f*; from *a* draw *a f*; *b a f* is an angle of 30°.

Fig. 3.

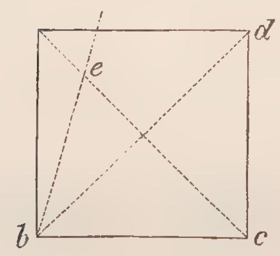


Fig. 4.

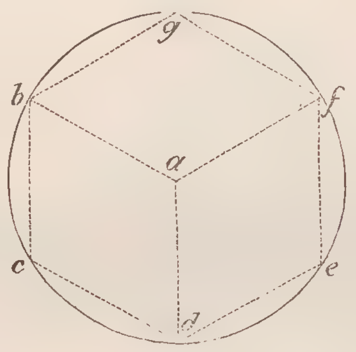
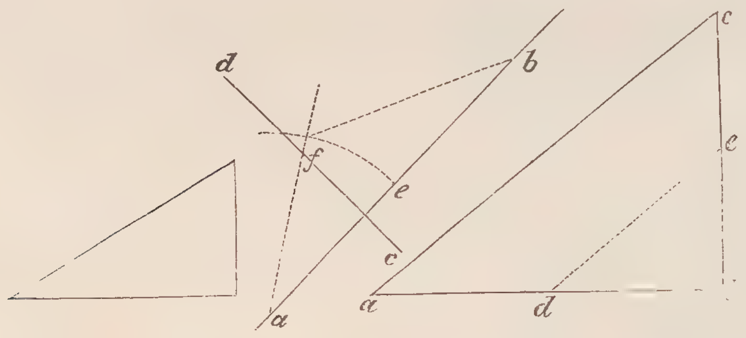


Fig. 5. Fig. 6.



6. An isometrical line being, as above stated, in proportion of 9 to 11 to a line of which it is the projection, an isometrical scale may be made by which a series of cubes may be projected in correct isometrical perspective. This scale may be made by drawing two lines, *a b*, *b c*, fig. 6, at right angles, making *b c* nine-elevenths of the line *a b*, and joining *c a*. Then make the line *a b* to represent an ordinary scale, say of eighths of an inch or inches, and suppose the point *d* to represent the position of the sixth inch; draw *d e* parallel to *a c*, cutting *b c* in *e*. Then the distance *b e*, taken in the compasses, will be the isometrical projection of a line, say 6 inches long, of which the correct scale is given in the line *a b*. The use of this scale in projecting circles will hereafter be described.

7. As before defined, a cube is a solid body, having six equal sides, of which all the sides are equal; in the isometrical projection of a cube, as in fig. 2, three of these sides are shown; of these three we designate the side *c* the upper side, *d* the "left hand," and *e* the "right hand" sides. Now, by cutting these sides by lines parallel to them, the representation of right-lined and rectangular objects will be obtained with great facility. Thus, in fig. 7, where the cube is shown by dotted lines, a slab is shown in its interior standing vertically; in fig. 8 it is shown horizontally. In fig. 9 three slabs are placed vertically, the outer, or right-hand one, having a square aperture cut in it. In fig. 10 two blocks support a third, and on this two others rest, one of these having a notch cut in it. In fig. 11 a horizontal slab supports a vertical block. Fig. 12 represents a hollow box, with square apertures in each side. Figs. 13 to 16 explain themselves; fig. 14 may be supposed

Fig. 7.

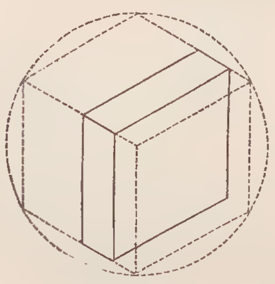


Fig. 8.

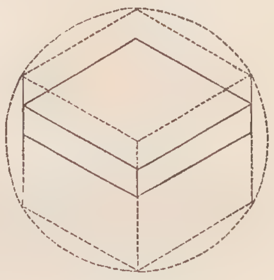


Fig. 9.

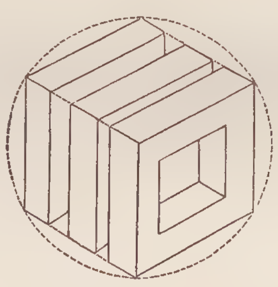


Fig. 10.

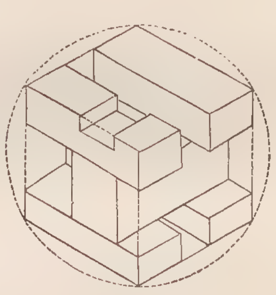


Fig. 11.

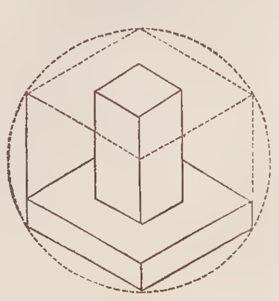


Fig. 12.

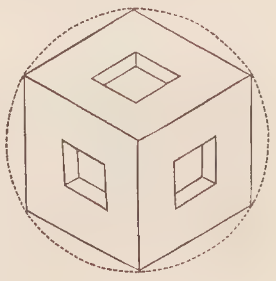


Fig. 13.

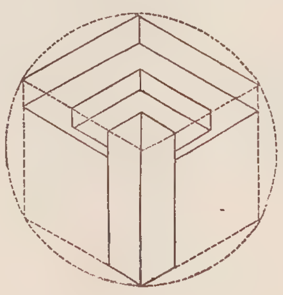
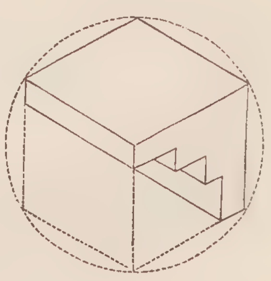


Fig. 14.



ISOMETRICAL PROJECTION.

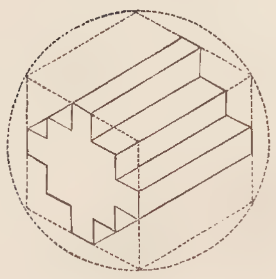


Fig. 15.

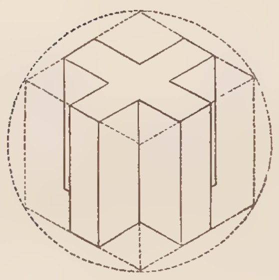


Fig. 16.

to be the projecting sailing courses of a chimney-stack. Fig. 17 represents a piece of timber with a notch cut in it, into which fits the projecting part of the upper piece of timber. Fig. 18 shows a box with one side open, and a projecting snug on right-hand side.

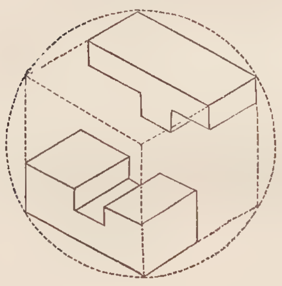


Fig. 17.

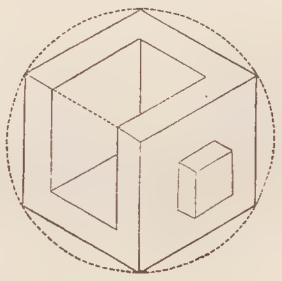


Fig. 18.

8. We now come to the delineation of subjects in which angular surfaces are presented. Fig. 19 represents the method of making a "scale of tangents" useful in cutting the isometrical planes at any angle. For this method we are indebted to Mr. Jopling's work, "The Practice of Isometrical Perspective" (published by Taylor, Walton, & Maberly), which we cordially recommend to the student desirous to master the mathematical principles of this perspective. Let *a b c d* be the side of a square. From *a*, with radius *a b*, describe the arc *b c*. Divide this into nine equal parts, and through these draw from the point *a* lines cutting the sides *c d*, *d b*. Divide each of these parts into two equal divisions, and draw lines as before. The line *b d* will form "a scale of tangents to 45°," ending at the point *d* at 45°. Next construct an isometrical cube, as in fig. 20, of which the side *a b* will be in *isometrical proportion* (see par. 6) to the side *a b* of the square, in fig. 19. Produce the lines *c g*, *g e*, fig. 20, as *g i*, *g h*. Parallel to the side *e f*, fig. 20, draw a line *i h*, exactly equal to the line *b d*, fig. 19. Then on the line *h i*, fig. 20, set off the distances *b* 10, *b* 20, *b* 30, *b* 40, taken from the line *b d*, fig. 19; and from these points on the line *h i*, fig. 20, draw lines to the point *g*, cutting the line *e f* as shown. A scale of tangents to 45° will thus be formed on the line *e f* of the cube. The divisions denoting the 5th, 15th, 25th, 35th, angles on the line *b d*, fig. 19, may also in like manner be transferred to *e f*, fig. 20. These divisions may then be transferred to the other sides of the cubes, *a g*, *a b*, and so on, till all the sides are formed into scales of tangents, each of which may be applied two ways, or twenty-four ways in all. The square *a e f g*, fig. 19, is a square equal in dimensions to that *a b c d* in fig. 3. The reader will at once see the applicability of these lines to the cutting of the cube in a great many directions. Figs. 21 to 26 will fully explain themselves, and indicate the way in which angular surfaces may be delineated.

Fig. 19.

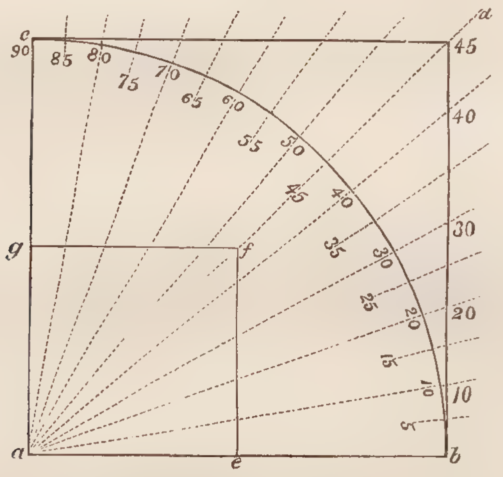
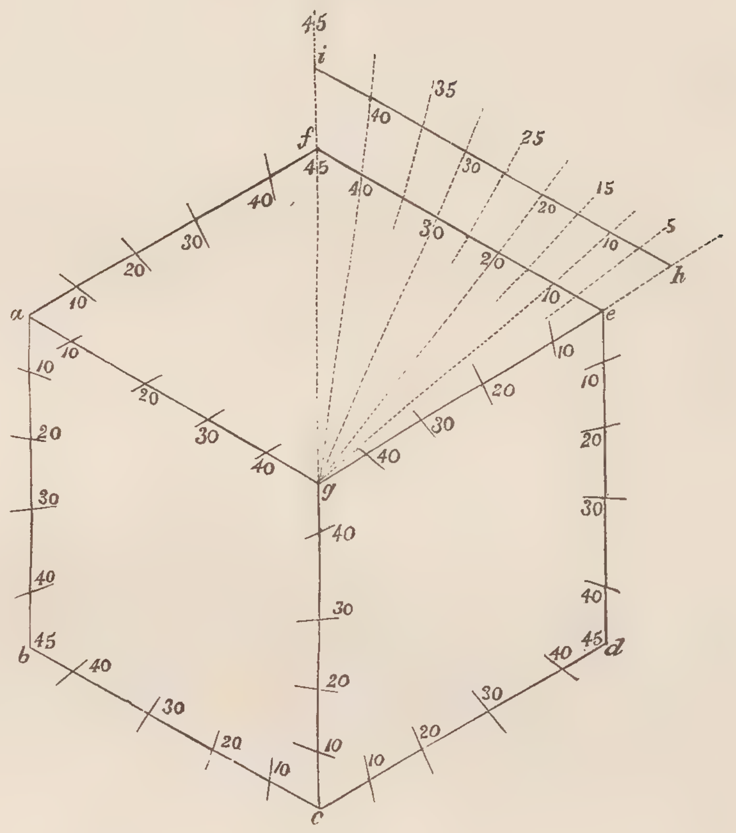


Fig. 20.



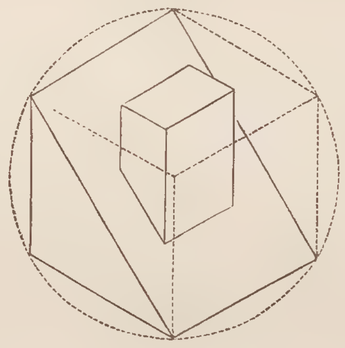


Fig. 21.

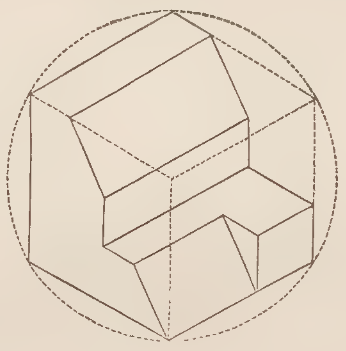


Fig. 22.

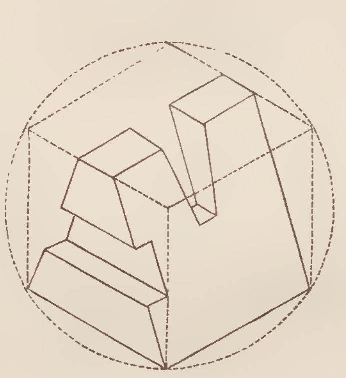


Fig. 23.

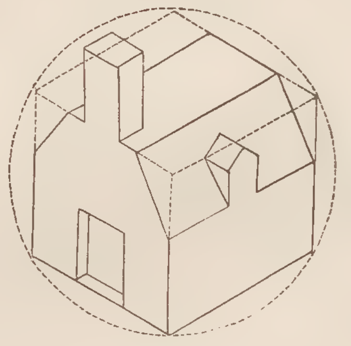


Fig. 24.

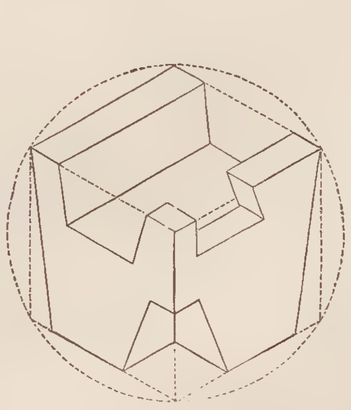


Fig. 25.

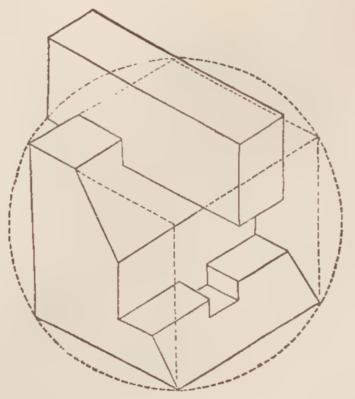


Fig. 26.

9. The method by which circles are described isometrically now claims our attention. Let *a b c d*, fig. 27, be the circle of which an isometrical projection is desired, and of which *e* is the centre. About the circle describe the square *f g h i*. Next project a cube, of which the side *a b*, fig. 28, is in isometrical proportion to the line *h i*, fig. 27. In the upper face of cube, *a b c d*, fig. 28, draw the diagonals *a b c d*, cutting each other in the point *e*. Make *e f*, *e g*, equal to the diameter *e c* of the circle in fig. 27. From *f* and *g* draw lines parallel to *a b c d*, cutting the line *a c* in the points *h* and *i*. Parallel to the sides *c b*, *a b*, draw lines through the point *e*, cutting the sides *d a*, *a b*, *b c*, *c d*, in the points *n*, *l*, *m*, and *k*. Eight points, *n*, *h*, *l*, *f*, *m*, *i*, *k*, and *g*, are thus obtained, through which, by hand, the ellipse or oval may be drawn. If the representation of a cylinder is required, the same process must be repeated in the lower side of cube *o p q c*, so as to obtain the part of the circle equal to the part *g k i m* and *f* of the upper circle; the cylinder is completed by drawing the lines *f s g r* parallel to *b g d o*. Fig. 29 shows a circle projected in the left hand, and fig. 30 in the right hand plane or side of a cube. Figs. 31 to 40 show the delineation of various forms of circles, with rectangular and angular surfaces

Fig. 27

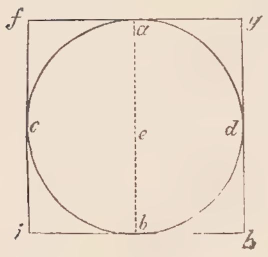


Fig. 28.

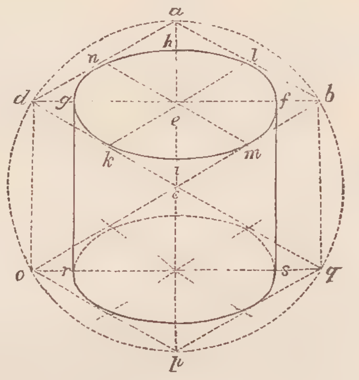


Fig. 29.

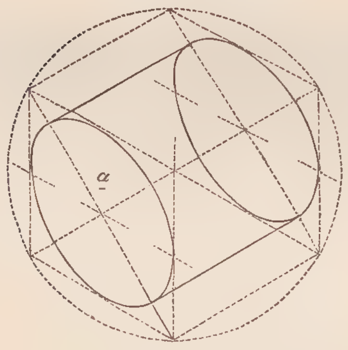


Fig. 30.

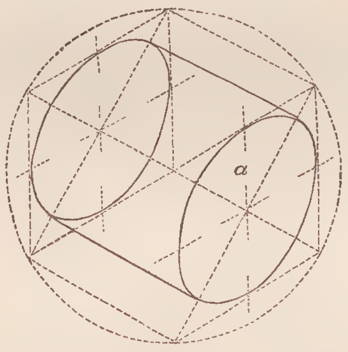


Fig. 31.

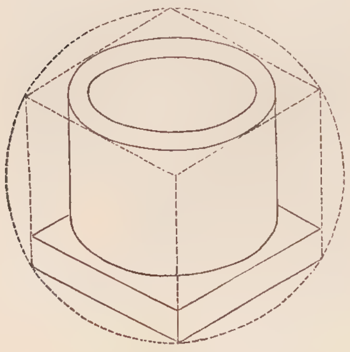


Fig. 32.

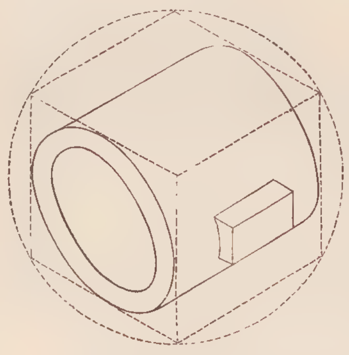


Fig. 33.

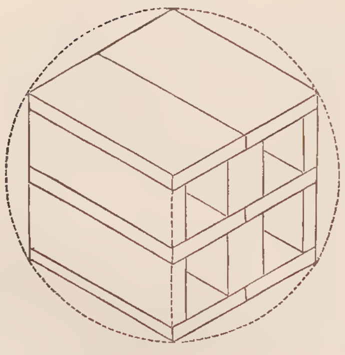


Fig. 34.

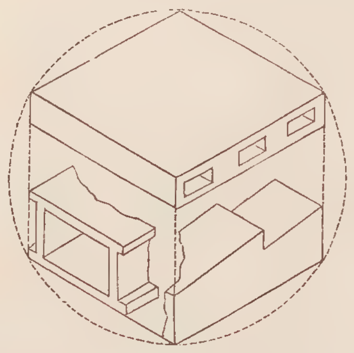


Fig. 35.

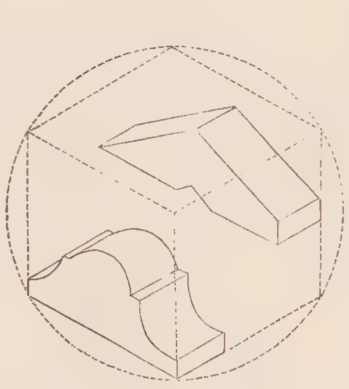


Fig. 36.

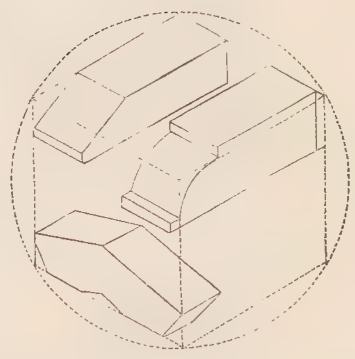


Fig. 37.

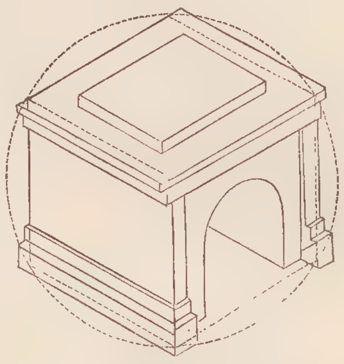


Fig. 38.

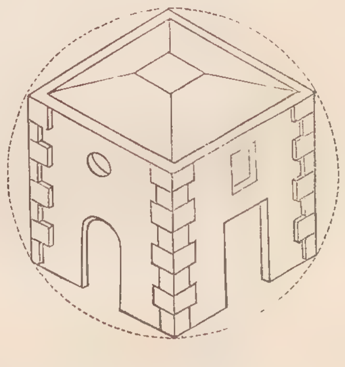


Fig. 39.

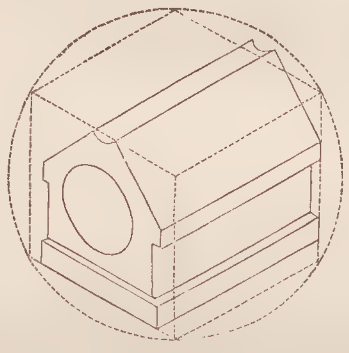
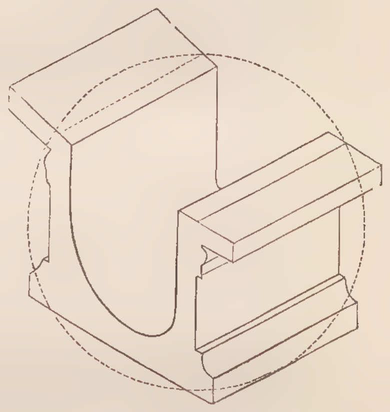


Fig. 40.



10. We now explain a method of projecting isometrical circles by means of scales. Draw two lines *a b*, *b c*, fig. 41, at right angles, *a c* being equal to *a b*. Take the distance *c a* in the compasses, and set off this distance from the point *a* to the point *d* on the line *a c* produced. Divide *a d*, *a b*, into the same number of equal parts, each of which may represent feet or inches. All isometrical projections of circles being ellipses, the major and minor axes will be found on this scale. Thus, if the distance *a d*—which we suppose to be 11 inches—represents the true diameter of the circle to be projected, then the distance *d b* will be the major axis, and *a b* or *a c* the minor axis of the ellipse or isometrical projection of the circle. The following is the method of using this scale in fig. 41:—Let the line *a b*, fig. 42, represent the diameter of the circle of which an isometrical projection is required; and suppose further, that the circle is required to be delineated horizontally, or on the face of the upper plane of a cube, as in fig. 42. Take the distance *a b*, fig. 42, in the compasses, and lay it on the line *a d*, fig. 41, from the point *a*, so as to ascertain the length of it as indicated in the scale. It will in the present case be found to

Fig. 41.

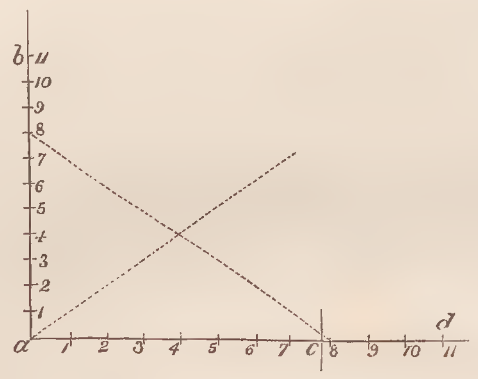
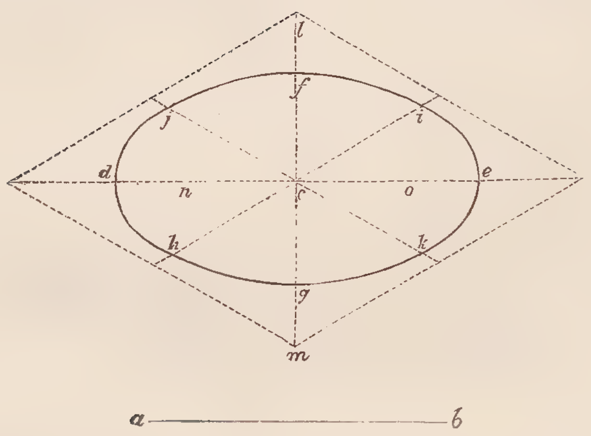


Fig. 42.



be 8 inches or 8 feet as the case may be. Take half the distance between the point in the line *a c* and 8 on the line *a b* (which can be done by joining them by a diagonal), and set off this from the point *c*, fig. 42, to the points *d e* on the line *d c e*, which represents the major axis of the ellipse to be constructed. Through the point *c* draw a line *g f* at right angles to *d c e*. Take the distance of four divisions from *a b*, fig. 41, and set them off from the point *c* to the points *f* and *g*. Through the point *c* draw a right-hand isometrical line *h c i*, and through the same point a left-hand isometrical line *j c k*. Take the distance of four divisions in the line *a d*, fig. 41, from the point *a*, and set it off from the point *c*, fig. 42, to the points *h i*, *j k*. Through the points *d*, *j*, *f*, *i*, *e*, *k*, *g*, and *h*, draw by hand the curve of the ellipse. By far the greater portion of the curve may be described with the compasses—these eight points being first obtained, as above described—the centres of the parts *j f i* and *h g k* being found in the line *f g* produced at *l* and *m*, and the parts *h d j* and *k e i* at *n* and *o*. These arcs, described by compasses, will not meet, but the short portion of the ellipse not described by the compasses can very easily be drawn by hand. Fig. 43 shows the projection of the same circle, of which the major axis, *d c e*, is in a right-hand isometrical line. Fig. 44 is the same circle projected on a left-hand isometrical line. The same letters of reference and description apply to these two figures as to fig. 42.

Fig. 43.

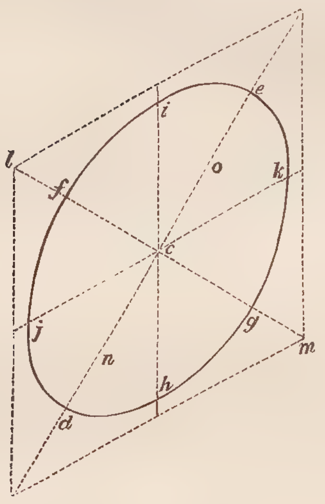
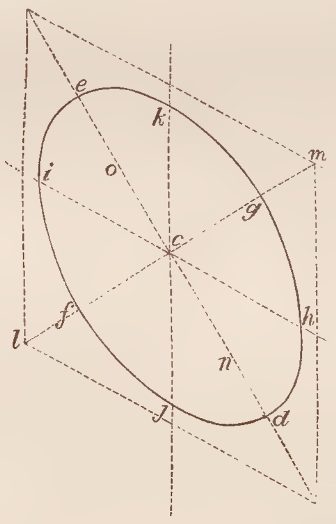


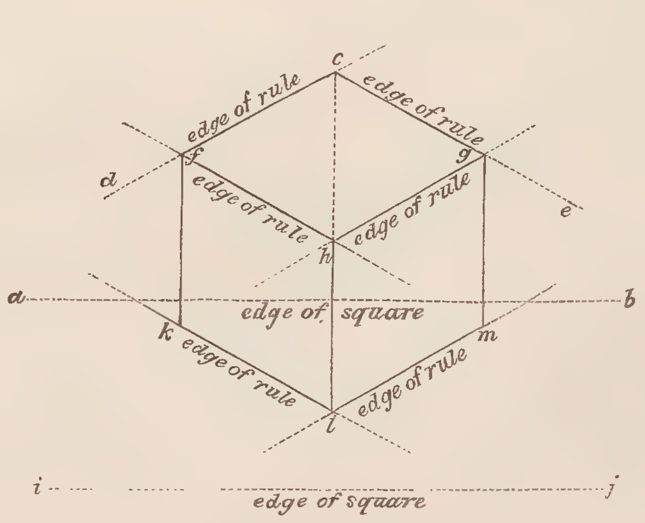
Fig. 44.



11. We have now given a number of examples from which the reader has been able, we hope, to gain a pretty fair notion of the mode of drawing a variety of forms within cubes. The more thoroughly the describing of forms *within cubes* is understood, the more easy will be his practice in another branch of the art, to which we now direct his attention, and in which the tedious modes of obtaining the *direction* and the exact *proportion* of isometrical lines already described, are dispensed with, and a mode as simple as it is practically useful is substituted. In fig. 5 we give the mode of constructing an isometrical ruler, *a f b*, of which both sides are angular; we also show in the same figure another form of ruler, having one perpendicular side, the angle being, of course, the same as the angle *a f e* or *b e f*. The reader desirous to practise this species of delineation should construct scales, of convenient sizes, of both these forms, and cut them out on mahogany or bay-wood. A complete set of isometrical rulers, with book of instructions, may be bought at Mr. Weale's, the architectural publisher, High Holborn, London.

12. We now propose to explain the mode of using the isometrical rulers. This must be done in conjunction with the common drawing-board and T square, so familiar to all architectural draughtsmen. Let the line *a b*, fig. 45, represent the upper edge of the T square, which is supposed to be lying along the drawing-board. Take any point *c*, and moving the isometrical ruler, as in fig. 5, along the edge *a b* of square, till the point *c* coincides with the angular edge of the ruler, draw through the point *c* a line along its edge, as *c d*; this will be a right-hand isometrical line. Move the ruler along the edge of the square till the angle points the other way, and till its edge coincides with the point *c*, through which draw a line *c e*; this will be a left-hand isometrical line. Let *c f* be the length of one of the sides of a cube which it is desired to draw. Set off from *c* on the lines *c d*, *c e*, this distance to the points *f* and *g*. Adjust the ruler till the angular edge coincides with the points *f* and *g*, through which draw lines, meeting in the point *h*; *c f h g* is the upper side of the cube. From *f h* and *g* draw perpendicular lines parallel to the diagonal *c h*. Lower the edge of square *a b* till it is at a point, say *i j*. Then make *h l* equal to *c f*, and adjusting the ruler till its edge coincides with the point *b*, draw isometrical lines along its edge, joining *f k*, *c m*, in the points *k m*. The cube is thus completed.

Fig. 45.



13. In fig. 46 we give at *a* the plan of top, at *b* the side, and at *c* the end elevation of a box, all of which are comprised in one isometrical drawing, as in fig. 47, the mode of construction of which we now explain. Draw a right-hand isometrical line *a b*, fig. 47, making it equal to the line *e d* in fig. 46; next draw the left-hand isometrical line *a c*, fig. 47, equal to the line *f g* in fig. 46. From the points *b c*, fig. 47, draw isometrical lines, meeting in the point *d*; *a c d b* will be the isometrical projection of outline of top of box shown in plan

Fig. 46.

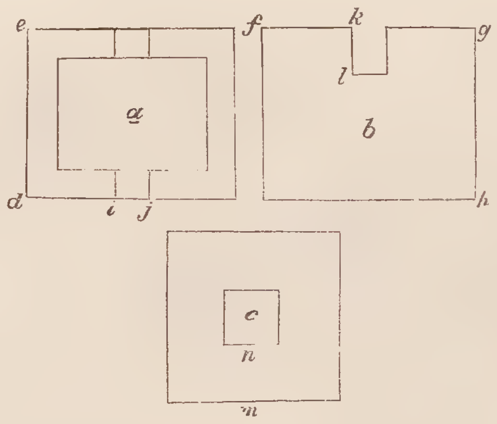
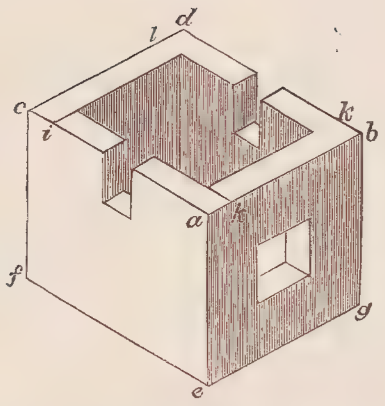


Fig. 47.



a, fig. 44. From *a c* and *b* draw perpendicular lines *c f*, *a e*, *b g*, and make them equal to the line *e d*, fig. 46. From the point *e*, fig. 47, draw isometrical lines to the points *f* and *g*. The rectangle *c f e a*, fig. 47, is the isometrical projection of the outline of side of the box *b* in fig. 46; and the rectangle *a e g b*, fig. 47, of the end *c*, fig. 46. The thickness of the sides is shown by taking from the plan *a*, fig. 46, the thickness, and setting it off from the points *b*, *a*, *c*, and *d*, to *k*, *k*, *i*, and *l*; and from these points drawing isometrical lines, which, intersecting, form an inner rectangle, as shown in fig. 47. The method of filling in the notches on the sides and the aperture at the end is shown in diagrams, figs. 48 and 49, which, for convenience, are shown to a scale twice the size of that in fig. 47. To put in the notches at the sides of the box in fig. 47, draw, as in fig. 48, two lines, *a c*, *b d*, representing the edge of the box. From *a*, fig. 46, take the distance *d i*, and set it off from the point *a*, fig. 48, to the point *e*; set off the distance *i j*, fig. 46, from *e* to *f*, fig. 48. From *e* and *f*, fig. 48, draw isometrical lines to *h* and *g*. From *h*, *e*, and *f*, draw perpendicular lines, equal to the distance *k l* in *b*, fig. 46, *h i*, *e j*, and *f k*. To draw in the aperture in the end of fig. 47—Let *a b c d*, fig. 49, represent the end *a b g e* in fig. 47. Take the distance *m n* from *c*, fig. 46, and set it off from the points *d b a* and *e*, fig. 49, to the points *e f g* and *h*. From these draw lines as shown in drawing, forming the inner square *i l k j*. From *k* draw an isometrical line *k m*, and make it equal to the thickness of the edge of box. From *m* draw another isometrical line *m o*, and a perpendicular line *m n*.

Fig. 48.

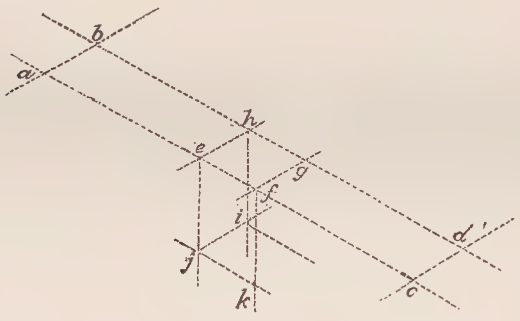
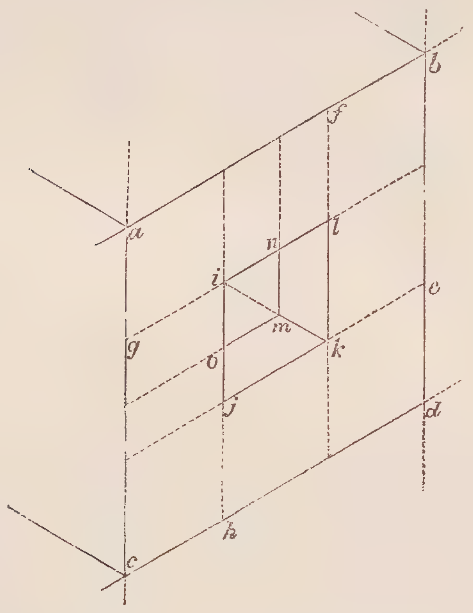


Fig. 49.



14. Proceeding to other examples, we give in fig. 50, at *a*, the plan, *b* the section of a slop-stone, and at *c* an isometrical view of it. In drawing this proceed as in fig. 51, which, for convenience, is shown of double the size. Draw two isometrical lines *a b*, *a c*, fig. 51, and make *a b*, *a c*, equal to *d e*, *d f*, fig. 50; draw the perpendiculars, *c f*, *a d*, fig. 51, and make them equal to the depth of end *g*, fig. 50. Join *d f*, *d e*, and from *f* and *e* draw isometrical lines cutting in *g*. From *f*, fig. 50, measure to *h*, and set off this distance from *g* to *h*, fig. 51; draw *h i*, and finish as in the drawing.

Fig. 50.

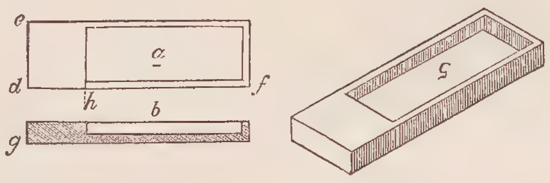
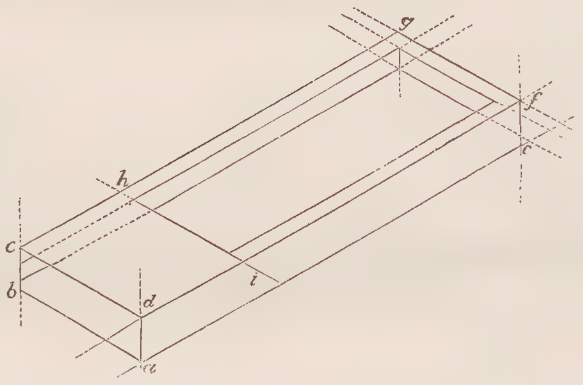
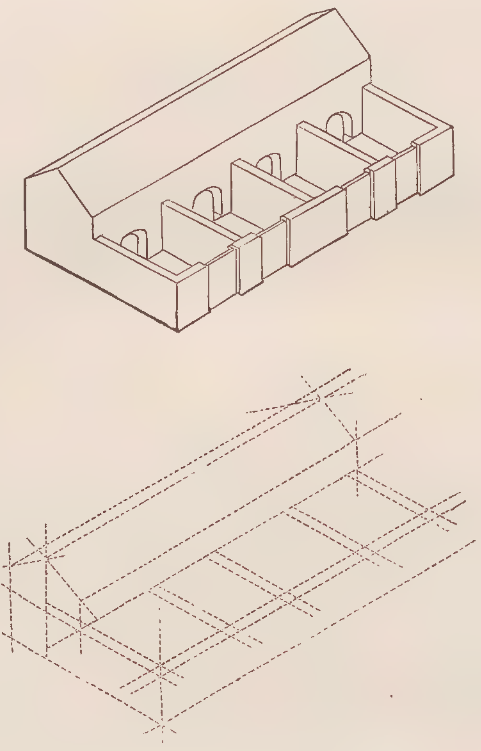


Fig. 51.



15. In fig. 52 we give an isometrical drawing of the piggeries belonging to the plan of farm buildings in Plate XVI., and in same figure a diagram in dotted lines, showing the mode of drawing this. All the measurements are taken from the plan in Plate XVI. and applied to the isometrical lines in fig. 52.

Fig. 52.



16. In fig. 53 we give an isometrical elevation of part of the range of cattle feeding-boxes in Plate XVI.; and in fig. 54 plan of the same, showing the internal arrangements. This fig. 54 shows how, by dotted lines indicating the roof and door lines, one drawing may be made to serve the purposes of plan

Fig. 53.

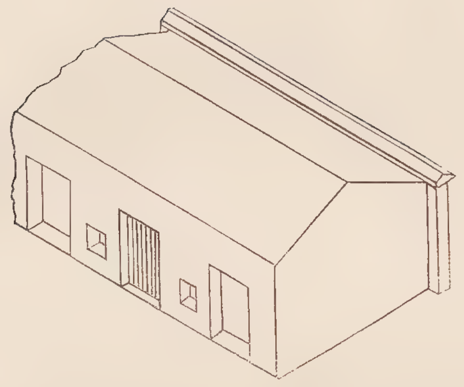


Fig. 54.

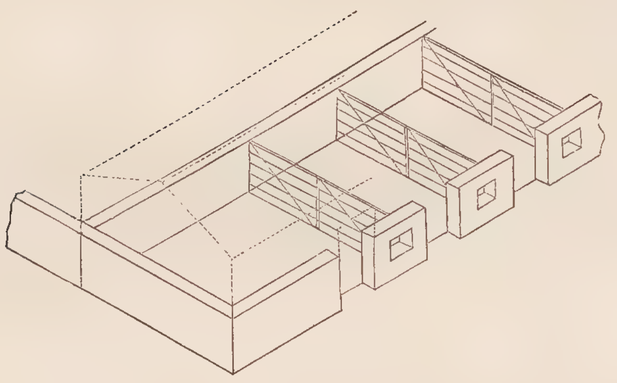


Fig. 55.

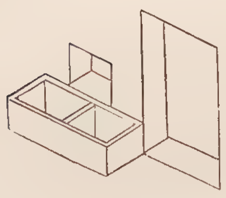


Fig. 56.

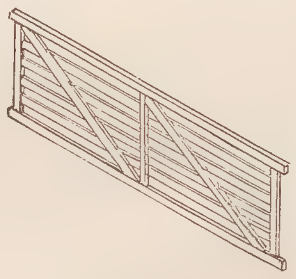
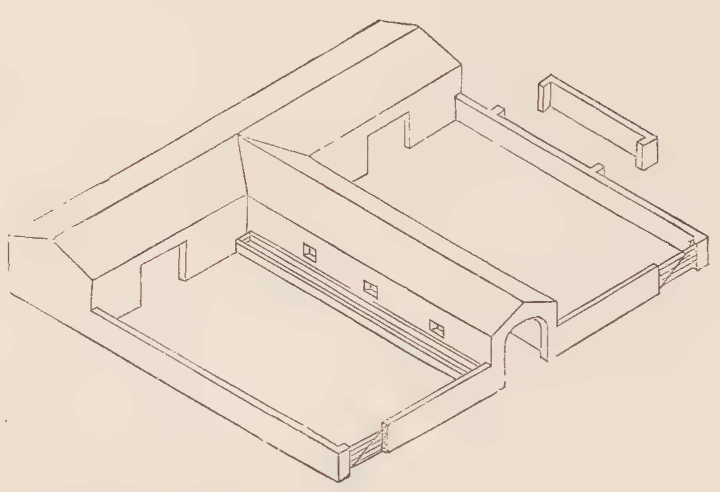


Fig. 57.



and elevation in one. Admirable examples of this useful style of combination will be found in the "Book of Farm Buildings," published by Blackwood & Sons, Edinburgh and London. In fig. 55 one of the feeding-troughs of the cattle-boxes (see plan in Plate XVI.) is delineated on a larger scale, and in fig. 56, one of the gates or hurdles dividing the boxes. Fig. 57 is an isometrical drawing of the cattle-courts and turnip-houses shown in the plan in Plate XVI. In Essay First, at figs. 31, 32, 33, 34, 35, and 36, will be found further illustrations of this mode of delineating architectural plans.

17. One great advantage of the mode of putting in isometrical lines by means of the drawing square and "isometrical ruler," is, that the same scale which is given for the ordinary plan serves for the isometrical drawing, so that an ordinary plan can be made from an isometrical one, and *vice versa.* Isometrical lines thus drawn are not in strict isometrical projection, but this is of no real consequence. Where lines are required to be in proper proportion, we have given ample instructions how to make them. We have not entered into all the abstruse elements of isometrical projection, nor have we deemed it necessary to do so; enough has been done, if it has been done so that the reader has been able to comprehend it, in explaining briefly and simply the modes to be adopted in throwing quickly into this attractive and useful species of projection many of the forms and arrangements used in architectural delineation. The diagrams in some instances may appear intricate and difficult; but by the frequent use of the compasses, the square, and the isometrical ruler, the difficulty will be found to be apparent; and in a very short space of time the tyro will be surprised to find how quickly he has acquired the general details of the art. There is, indeed, no species of projection so easily understood, so rapidly learned, and so widely applicable to the delineation of architectural subjects, as that which has formed the subject of this Essay. It will be gratifying to its author if his readers will find it so, and if his remarks and illustrations have in any useful measure helped them toward attaining rapidly a knowledge of its practice.

ON SPECIFICATIONS AND ESTIMATES.

1. In presenting the following paragraphs to the notice of the reader, it is necessary to premise that they are designed chiefly for those commencing the study of the profession, and who may be desirous to have what may be termed models for practice in this one of its most important departments. Further: they may be useful as conveying some hints to parties intending to build either on their own account or for purposes of investment. But while thus more specially addressing the uninitiated, the author of the present paper ventures to hope that some of it may be of practical service to the more experienced of the profession who may favour it with a perusal, as indicating the requirements of a certain class of structures—farm buildings—with which they may have no direct professional connection, yet in which they nevertheless may feel interested, and desirous to become acquainted with their structural requirements.

2. In drawing up the specifications of any structure it will materially assist the young practitioner, and prevent him from making important omissions, if he has prepared for consultation a paper containing, under the several heads, a series of items to be remembered. Thus, under the head of *Excavator*, let the various points be noted, as digging out trenches for footings, cellars, piers, drains, and the placing of concrete in the trenches if required. Under the head of *Bricklayer*, the points to be attended to are footings—course laid with tar, or sheet lead, to prevent damp—arched openings, cross walls, sleeper-piers, trimmer arches for fire-places, gauged arches, drains, water-closet pans, flues, setting of slop-stones in scullery, copper in wash-house, &c., ventilating-bricks, to secure current of air along joists and under flooring, &c. Under *Masonry*, ashlar, or rubble-door steps, landings, window-sills (throated and feathered), dressings to windows, doors, strong course quoins, cornices, pavements, tiles to lobby, slop-stones, sinks, chimney-pieces. Under head *Carpenter and Joiner*—Timber to be used: girders, joists, trimmers, rafters, hips, tie-beams, angle-ties, struts, purlins, quarterings, ridge-poles, king-posts, bond timber, boarding for floors, gutter-boarding, centres for arched openings, brackets, cantalivers, rolls, strutting to floor-joists, skirting-boards, window and door frames, shutter-boxing, shutters, architraves, mouldings, framed grounds, door-jambs, staircase (well or dog-legged), strings, nosings, hand-rail, balusters, steps and risers, brackets, fronts to closets, wardrobes, water-closets, casing to pipes, cistern, drawer fronts, dresser in kitchen, shelving in ditto. Under head *Ironmonger:* hinges, locks, finger-plates, bolts, sash-weights, sash-fasteners, window-blind pulleys, shutter-bars, door-chain, grates, stoves, ventilators. Under head *Plumber:* lead to gutters, rods, flashing to chimneys, cistern lining, pipes to water-closets, &c., sink traps, stop-cocks, bath and apparatus, lavatories. Under head *Plasterer:* ceilings, lath plaster (set and float), quarter partitions, walls, cornices, enriched centre pieces in stucco, *carton pierre*, or *papier maché*, cement to windows, doors, reveals, white-washing. Under head *Painter:* outside work, inside ditto, oil, graining, varnishing, window-frames, doors, architraves, wall papers. Under head *Glazier:* glass to windows, fan-light over doors. These items are by no means complete, but are given here simply to show the nature of the consultation paper we have recommended for the adoption of the young architect.

3. Let the wording of the specification be as plain as possible, carefully avoiding all ambiguity of expression, for the tyro should ever remember that the specification is the basis, the "soul"—to use an expressive French term—of the contract, defining exactly the nature of the work promised to be performed by the contractor, and expected to be adhered to by the proprietor of the building to which the specification refers. It will greatly facilitate a ready reference to the various departments of the specification if it is arranged, not only under general heads, as Mason, Carpenter, &c., but further, if it has marginal or paragraph references directing attention to the matter discussed in the part opposite to, or near, which the marginal reference is placed. In specifications for small and unimportant works this need not be attended to. The details of the work to be performed by the various artificers are usually preceded, in the specifications of important works, by what is denominated General Conditions, or Contract.

4. Before drawing up the specification, and, indeed, before making the working drawings, let the inexperienced architect—and, perhaps, the advice is valuable also to the experienced—be sure that his client knows perfectly the plan of the house he wishes; and before the plan is begun, let the proprietor of the proposed house make up his mind thoroughly as to the kind and extent of accommodation he requires or wishes to have in the house. Some may think this a very easy matter to do; that it is not easy, anything but that; in point of fact, a thousand and one evidences are now standing perpetuated in brick and stone, lime and timber, in various parts of the country, to testify how the owners must have been in a mazy muddle when planning, or attempting to plan, or while examining the plan prepared by others, so far as the number of rooms, relative positions of the same, not forgetting dimensions, were concerned, inasmuch as after taking possession, deep disappointment and blank amazement has been their lot; for truly the houses they now inhabit are not what they expected them to be, and, indeed, had persuaded themselves they must be. Architects are too often oblivious of the fact that clients have no real notion of a plan as usually drawn; walls, partitions, lobbies, rooms, are all

one to a certain class of the building speculative mind, so much so, in point of fact, that we were by no means surprised to hear it stated by one who had built a house, that he had really no idea it would have had so many rooms in it. A shrewd man withal in his own business, and by no means of the wooden-headed species of men. Yet to him who had a sharp eye for a bargain, or the weak point in a settlement, the plans—professedly pored over and seriously studied—had been to him but as little more—if, indeed, any more—than blank paper. The simple expedient, as suggested by a non-building friend, would seem to have met the difficulty—"Did you not think of reckoning up the number of fire-places in the plans? this would have given you the number of the rooms." But this would in no thorough way have solved it, if, indeed, in any way; for how, or in what manner, the plan-puzzled man could have distinguished a fire-place in the plan is the thing to be thought of, the "plan-indication" of a fire-place being to him as dark, obscure, or utterly unknown, as that of a room, much more so, one would think. This matter is not, as the reader may suppose, of no moment; it is of vast moment. If to satisfy one's client be a weighty matter, as we venture to say with all conscientious architects it really is, then all means by which the satisfaction of the clients *can* be secured should be attended to. A little pains, therefore, should be taken to get the client indoctrinated—"insensed," as a provincial most expressive phrase goes—as to the real arrangement, number of rooms, &c., &c., of the proposed house. With the majority of non-architectural men, a plan—in plano—is really, as we have hinted, a very difficult thing to understand. We know of no mode of delineation so simply carried out by the architect, so easily understood by the client, as the *isometrical.*[*] By this mode the drawing is so "model like," that the examiner may fancy that he is walking in and out of the apartments. If any client *cannot* understand this kind of plan, why, with all ease of mind, the architect may trouble himself no more on the matter, nor cudgel his brains to find out some mode of "insensing" him; the client is clearly of the "insensable" class, of the wooden-headed species truly, and in every way fitted to live in any kind of house, however badly arranged it may be.

5. The client being then supposed to understand a plan, let him, as we have before recommended him to do (see beginning of par. 4), study it well, so that the house it represents shall really, fully, and truly, afford him precisely the kind and extent of accommodation he requires. After he has this decided, let him hand over the plan to his architect, as forming the basis of the contract to be made, and determine *that no deviation whatever shall be made from this plan after the building of it is fairly commenced.* All deviations, let it ever be remembered, but open the door to the charging of "extras," and these, when once allowed and made, we may say—without in any way wishing to perpetrate a pun—give rise to extraordinary dissatisfaction on the part of the client. Keep to your plan, we again advise you, and you will ultimately know, as you take possession of your house, and sit comfortably down at its fireside, what it has really cost you; deviate from it, and although you may still know the exact amount it has cost you, you never will know how or in what manner the *extra* cost has been incurred. In this state of mind a client never will be satisfied, of which fact let architects duly take note, and, noting, remember.

6. So much of advice to clients; let us return to our advice to the young architect engaged in drawing up a specification. We have pointed out the parts of a specification, we now deem it necessary to elucidate our remarks by a practical example. First, as to the title. This simply points out the character or nature of the structure proposed to be erected, the name of the client for whom it is intended, the name of the architect by whom it is designed, and the number, and sometimes the title, of the various plans to which the specification refers. It may run thus:—

7. Specification of the materials to be employed, and of the work to be done, in the erection of a —— (here name the kind of structure, dwelling-house, villa, cottage, farm-building, or the like), for —— —— (here name the proprietor), in accordance with the drawings prepared, provided, numbered (and titled), as follows, by —— —— (here name the architect). No. 1 (here number, and if thought necessary, name the different sheets of drawings).

8. The general conditions or contract should be carefully drawn up. These conditions, among other things, should specify that the drawings are to be considered as equally binding on the contractor or contractors with the specification. Further, that if any point is omitted either in the drawings or in the specifications, which is usually noted or given in them, and which may be inferred from them, the contractor or contractors have not the liberty to make the contract void, or to take any undue advantage of the same. The "true intent and meaning" of the drawings and specifications must be the guide, and all material and all labour in using these must be provided accordingly. Should the drawings give rise to any doubt as to the exact measurements indicated or intended to be indicated, or taken from the scale attached to the drawings, the figures given on the plans or in the specification to be preferred to the measurements taken from the drawings and scale. When a dispute arises on any point connected with the drawings and specification, the architect is to be appealed to, and the general conditions should carefully specify that his decision is to be final; the decision also to be given in writing. It should also be stated that the contractors are to provide all the materials, working tackle, plant, tools, and all requisites for the proper carrying on and finishing of the work specified. These are all to be the best kind, and the soundest workmanship. The whole works to be carried on, completed, and finished to the satisfaction of the architect. The contractors are also to be bound to clear away all rubbish material at such time as the architect may direct; and to leave the ground, on completion of the works, in a condition satisfactory to him. The mode and times of making payments to the contractors should also be specified in the "general conditions." A usual way is to make payment to the bricklayer, mason, and carpenter, in three instalments—each instalment to be not less than twenty per cent. of the amount of the respective contracts of these tradesmen. The proprietor is not, however, to pay these instalments unless a written certificate signed by the architect is presented, showing that the amounts or sums which may at the time be applied for are not more than seventy-five per cent. of the value of the work at that time executed. This value should be computed at the rate at which each contractor has furnished his estimate. Should the contractors become bankrupt before the completion of the works, the "conditions" may contain a clause specifying that the decision of the architect as to the amount of each instalment and time of payment to be made to the official assignee or assignees is to be final. It is usual to defer payment of the bills of the plasterer, painter, slater, and plumber, till the work contracted for by them is fully executed and completed to the satisfaction of the architect. The "conditions" should also contain a clause specifying that the proprietor is at liberty to make alterations or additions to the work as it proceeds; and that although these may be made, the contract is not to

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[*] This isometrical plan is, of course, only recommended as an aid to the imagination of the client, who may be really desirous to come to some kind of understanding as to what manner of house accommodation he is really to have. It is not meant to supersede in any way the plans as usually constructed. See the Essay on "Isometrical Drawing as applied to the Delineation of Architectural Subjects" in this work.

be rendered null and void in consequence. But no "extras"—incurred by, or involved through, the making of these alterations or additions will be allowed for, if the order is stated to be, or was stated to have been, given verbally. The contractors will, therefore, be bound over to produce a written order from the architect. Where extra work is to be done, it is well to stipulate that it shall be contracted for before the work is begun to; failing this contract being done, it shall be competent for the architect, or party named by him, to have the extra work when finished measured and valued, the valuation thus made to be final and binding on the contractors. Further, to provide for cases where some of the work originally designed to be carried out, shall not be so carried out, a clause should be inserted in the "conditions" stating that all work not carried out shall be measured and valued by the architect, or person appointed by him; the valuation being made at the same rate at which the architect considers the contractor has valued his contract. The amount of valuation thus fixed upon to be deducted from the full amount of the contractor's estimate. The "conditions" should also specify the power which the architect has to order the contractors to replace with good materials and workmanship such materials and workmanship as he may deem bad; and in the event of the contractor's refusing to replace such bad materials and workmanship with good, to the complete satisfaction of the architect, within a certain time (to be named), after he has sent the contractors a written notice of his wishes, then the architect shall have the power to re-let the work to other contractors; and further, should any loss through this be the result, this loss to be made good by the original contractors. The original contractors should be bound not to sub-let the works, or any portion of them, without the written consent of the architect. The whole of the works and the necessary material required to carry them out are to be under the care of the contractors, who are also to be liable for all loss and damage which may be incurred through fire, storm, or tempest; and all damage so done must be repaired by the contractors. The works to be commenced by an order from the architect, and the date of this order to be the date from which the time of contract is to be dated. The contractors being bound down under a penalty of a certain sum per day for each day they are beyond handing over the works completed to the satisfaction of the architect. The bricklayer, mason, and carpenter, are usually separately, in large structures, bound down to have their work done—under penalty as above stated—by a certain date, ready for the slater and plumber to begin their operations. The slater and the plumber are, on the other hand, bound down to commence and finish their work within so many days after the order to begin has been handed them by the architect. None of the materials to be removed from the ground without the permission of the architect; and it will be as well to provide that all the materials, the building itself, as it progresses, and the ground on which it stands, are to be considered as the property of the landlord or proprietor, although he, at the same time, is not to be liable to any risk of fire, &c., this being provided for by separate clause, as already stated.

9. *Examples of Specifications.*—The following examples will be useful to the tyro, as explanatory of some of the modes in use for drawing up these important documents. The first is for a dwelling-house, of which we give the plans in Plates XIII. and XIV.

> Specification of work to be done in the erection of a dwelling-house at —— ——, near ——, for Mr. ——, agreeably with plans, elevations, and sections, prepared by Messrs. —— ——, ——, & Co., architects, ——.—*March* 1863.

CONDITIONS.

The contractor must clearly understand that all the works are to be executed in the best and most workmanlike manner, with materials of the best description, and of the best quality of their respective kinds, with good and efficient workmen, and to the satisfaction of the proprietor or his architect.

Any alteration in the building that may hereafter be made by which the charge of the contractor may be lessened or increased, to be adjusted and finally settled by the architect upon such terms as, in his opinion, the contractor was guided by in forming his estimate for the work under which the alterations may be denominated, as no alteration of any kind will be allowed to invalidate the contract.

The decision of the architect in all cases of whatsoever nature connected with these alterations to be final and conclusive, and without appeal; and should the contractor delay complying with his instructions, the architect shall have power to call in additional men from wheresoever he may think proper to follow his orders, and any payment he may make for such works done by them upon this building shall be deducted from the monies due to the original contractor.

Any materials which the architect may consider of a nature not calculated to carry out the works in conformity with the specification and drawings, to be at once removed from the premises upon notice in writing to that effect being left at the contractor's place of business; and the architect shall have the power of discharging any workman from the building, and to have a greater or less number set on.

The building must be left complete and perfect, and fit for occupation at the completion of the works; any defects appearing in the building for the space of three months after the said works are measured up, must be made good at the expense of the contractor.

The contractor shall not be paid for any material that shall have been altered necessarily from the contractor's neglecting to pay sufficient attention to the drawings and specification or instructions given, or for any materials that shall have been rejected by the architect. Nor will any extra be allowed for any thing or things implied by the specification; but the drawings and specification must be taken together, and the materials or workmanship necessary for completing the building to them must be provided, although an omission may happen in one or both. Should there, therefore, be any work or materials, usually considered necessary to complete the works, not shown on the drawings or described in the specification, or that are mentioned or explained in either only, the contractor must include the same in his tender, as if the same had been more particularly described and delineated, and generally must find and supply whatsoever may be wanting to complete the different works according to the true intent and necessary meaning of the specification and drawings; and any doubtful or disputed question arising on this or any other subject is to be decided by the architect, whose decision in writing shall be binding, and without appeal.

The contractor must execute all drawings that may hereafter be furnished, which are in accordance with the specification or nature of the work, and he is also to provide all boards for drawings.

The contractor must hold himself responsible and make good any damage that may in any way accrue to the building during the progress of the work.

The payments to be made by instalments in sums as shall hereafter be fixed upon, and in sums not less than fifty pounds upon the amount of the contract, on the applicant for a payment producing a certificate from the architect that the amount of the sums applied for and received does not exceed three-fourths of the value of the work then executed and performed, the value of such work to be computed by the architect after the same ratio of prices at which he conceives the applicant's tenders or estimates have been formed.

The buildings, and the materials upon the ground are at all times to be considered in the possession of the proprietor without nullifying or invalidating the contract in any particular; but the proprietor will not consider himself liable in any manner to any charge or risk, or any materials or other matters which may be lost, stolen, damaged, removed, or destroyed.

The works are to be commenced immediately after the signing of the contract, and the roof must be completed and finished on or before the tenth day of ——, one thousand eight hundred and sixty three; and the whole of the respective works are to be entirely finished on or before the twenty-sixth day of ——, one thousand eight hundred and sixty three.

And should the time for finishing the roofs and completing the whole of the works be extended over, above, or beyond the said respective periods of time hereinbefore mentioned, then, and in each and every such case, the contractor or contractors who may have caused such delay, by negligence or inattention, to the proper progress of the works, must pay the sum of two pounds per week as and for liquidating damages, anything to the contrary notwithstanding, for every week exceeding the said respective periods of time hereintofore fixed upon, unless it can be clearly shown to the satisfaction of the architect *that such delay has been occasioned solely by and entirely* by some of the *party or parties*, or in consequence of a combination of the contractor's workmen, or by the act of God.

The architect reserves to himself the power of refusing any sub-contractor whom he may consider not sufficiently competent to carry out the various trades to his entire satisfaction.

EXCAVATING.

Drains. The whole of the draining throughout will be done by the proprietor.

Soil. The contractor to take off the sods and soil for a superficial area of — yards by — yards, and wheel the same upon such part of the land as may be directed.

Trenches. To dig out the earth for the cellar and for the trench for the several walls to the depth shown upon the several drawings, and afterwards to level the bottoms of the trenches to receive the brick footings, and in all cases to allow sufficient working room on each side of the walls.

Filling in of soil. To completely fill in the earth against the walls as the work progresses, and well ram or otherwise effectually consolidate the same.

Earthwork for flagging. The contractor to fill up the earthwork to the scullery, pointing back passage for the reception of the flagging.

BRICKWORK.

Bricks. The whole of the common bricks used for building the several walls are to be laid square, and well burnt, and to be as free from limestone as possible, and no soft or unsound ones will be permitted to be used on any pretence whatever.

Mortar. The mortar to be composed of good, burnt Buxton lime, and good, sharp, clean sand, in the proportions of one-third of lime to two-thirds sand, to be thoroughly mixed, and kept from mud or dirt.

Footings The whole of the walls are to go to the depths and carried up the height and thickness shown and figured upon the several drawings; to be kept straight and plumb on each face, and no wall will be permitted to be advanced more than one scaffold height above any other part.

Foundations. Should any of the foundation walls require to go to a greater or less depth than are shown on the drawings, to ensure a solid foundation, the same to be added or deducted from the contract at the same rate of prices as originally estimated at.

Courses. All the brickwork is to be walled as thin in the joints as possible, the courses being kept even and level, and the perpends as uniform as the nature of the work will admit; and all the beds, returns, and cross-joints, to be well flushed up with mortar for the entire size of the brick, and no difference will be allowed in the quality of the workmanship to the inside walling.

Footings. The whole of the walls are to have two courses of footings projecting a quarter brick on each side thereof, and to break round all projections.

Cavity-walls. To build the exterior walls in front elevation (south) and side elevation (west) with an 11-inch cavity, and to be bonded together every fourth course in height and length with whole bricks and iron ties alternately, the external face to be executed with the best picked checker bricks, and to be neatly dressed off with putty.

To build the exterior walls to side elevation (east) and back elevation (north) with an 11-inch cavity wall, to be bonded together as before, the external face to be executed with the best picked common bricks, and to be neatly jointed.

Timber near flues No timber will be allowed to be inserted in the walls within 9 inches of any of the flues, and if any timber be found so placed, the same to be taken out and reinserted and made good, and all expenses incurred to be paid by the contractor.

Wall-plates. To bed in mortar all lintels, wall-plates, wood, bricks, stone sills, or any other materials intended to be set in the brick-work.

Fire-places. To form the several fire-places as are shown upon the drawings, gathering over the same with flags found by the bricklayer, and to form the several flues therefrom, and those jambs which have no flues are to be built up solid.

Flues. The flues are to be 14 × 9 inside measure, and to be roll-plastered with hair mortar, mixed with cow dung, great care being taken that the midfeathers are set close with whole bricks, well tied in and flushed up with mortar.

Relieving arches. Turn relieving arches in two half-brick rims, properly bonded the whole thickness of the several walls, and within half a brick of the external face of the exterior walls of such rise, and span, as may be directed, over all doors, windows, and fire-place openings, soughs, or such other openings, as may be found necessary during the progress of the work, all set close upon the face and soffit.

Door and window arches. Turn all external arches over all doors and windows, as are shown in the different elevations, and the whole to be neatly dressed off with putty.

Trimmer arches. Turn trimmer-arches to all fire-places.

Cornices. The cornices over bay and Venetian windows to be formed with brick, as are shown in the drawing.

Chimney-stacks. Carry up the several chimney-stacks above the roof to the form shown in the drawings, with all over-soiling, &c., and to be executed with the best seconds brick.

Sleeper-walls. Build, to support the joists of dining and drawing rooms, 4-2 inch sleeper-walls, with openings at intervals for the circulation of fresh air.

Cellar walls. The cellar walls to be pointed for whitewashing.

Gables. To cut all gables to the form shown on the drawings.

Cellar steps. To set the inside cellar steps as shown upon the drawings, and to build the brick rims, and to point the same.

Piers. To build 9-inch brick piers underneath the slop-stone in scullery.

Skewbacks. To form all projections, and all skewbacks, inducts, recesses, splays, &c., when and where directed, and to make good all beam-filling to the various eaves.

Air bricks. Provide 12 air bricks to be placed where shall be directed.

Grates The whole of the grates will be found by the proprietor, but to be fixed by the contractor, finding all fire and common bricks or other needful matters requisite for fully completing the same, and to form such necessary flues or work connected therewith.

Boiler in scullery. Provide and set up in scullery a 20-gallon boiler with good hard common bricks, with fire-bricks where exposed to heat, and to have strong wrought-iron furnace-bars, door, and frame, with latch complete.

Ash-shoot. Provide and fix a cast-iron door and frame to ash-shoot in cellar 2 feet by 1 foot 2 inches.

MASONS' WORK.

Stone. The whole of the stone required for the chimney-copings, window-sills, corbels, or any other parts so specified, is to be of a good quality of ——— stone, as free as possible from bands, rents, or other imperfections.

Mortar. The mortar used for the masonry to be of ——— lime and good clean sand, mixed in the proportions of 1·3 of lime to 2·3 of sand.

Sills To provide and work for the window openings to the west and south elevations 12 × 6 inch rubbed, weathered, and throated sills, truly set upon the brickwork.

Sills. To provide and work to the rest of the window openings 9 × 4 inch rubbed, weathered, and throated sills.

Copings. To provide and set upon the chimney-stacks, tooled, weathered, and throated copings, 4 inches thick, truly set upon the brick-work, and cramped at each joint, and covered with cement.

Cellar steps. Provide for the inside cellar steps 12 × 2½ inch flagged steps, with tooled edges, and to be the lengths as shown upon the drawings, and to have 4½-inch wall hold.

Front entrance door steps. The front entrance door-steps to be of hard Yorkshire stone, 12 × 6 inches, properly fixed into the brick-work, and knotched and holed for the door-frames, and a 3½-inch polished landing to porch in one stone.

Side entrance door steps. The side entrance door-steps to be 3 inches thick, and polished with brick risers.

Flagging. To provide and lay the floors of scullery, pantry, back passage, and cellar, with 2-inch self-faced Yorkshire flags, laid upon a bed of sand 2 inches deep, with the joints well and truly squared through, and well laid in mortar, with close joints, and neatly pointed with fine mortar.

Hearths. To provide and fix to the whole of the fire-places 2-inch polished Yorkshire hearths and back hearths, the hearths in each case to extend on each side 9 inches beyond the fire-place openings, and to project 24 inches from the face of the chimney-breast, the back hearth to be in one flag, and the whole to be truly squared, and laid upon a bed of sand and mortar.

Chimney pieces. The whole of the chimney-pieces will be found by the proprietor, but to fix in a workmanlike and substantial manner by the contractor.

Slop-stone. Provide and fix in scullery a 6-inch rubbed ——— slop-stone, of the size and form shown on the plan, to be dished out 3 inches, and properly holed for the stench-trap, and to be fixed upon brick risers.

Put round the slop-stone a 12-inch self-faced flag skirting, well cramped to the walls.

Boiler flag Provide and fix upon the boiler in scullery 3-inch self-faced ———

flag, with the edges tooled, and the flag to be in one, and the hole cut through the same to receive the boiler, and fix the flag with strong mortar upon the brick-work.

All damage done to the flagging or stone-work, by whomsoever caused, is to be made good by the contractor without any additional or extra charge, and no broken or cracked flags or stone will be allowed to remain in the building at its completion on any pretence whatever.

Corbels. Provide and fix stone corbels under cantilivers, or brackets, in each gable as shown in the drawings.

CARPENTERS' AND JOINERS' WORK.

Bearing timber. The whole of the bearing timbers required about the building (except herein otherwise so directed) is to be sound American spruce deal.

Sash-frames timber. The timber used for the sash-frames and sheets are to be out of St. Petersburg red deals.

Timber for inside work. The timber used for the inside joiners' work to be out of St. John's yellow pine, well seasoned, and free from knots.

Timbers. All the timbers are to be cut die square, and slabbed, and to be the thickness specified when cut, and to be free from sap-wood, shakes, or large loose dead knots.

Wood bricks. Provide and fix wood bricks 9 × 3 to all door and window openings requiring the same.

Lintels. Provide and fix lintels over all door and window openings requiring the same, and to be the width of the walls, and within half a brick of the external walls; the lintels to be not less than 3 inches thick, and to have 9-inch clean wall-hold at each end.

Provide and fix over the openings of bay and Venetian windows for the support of the brickwork, two pieces, each 14 × 8, and to be well bolted together, and to have 12 inches clear wall-hold at each end, laid upon wood templates 9 × 3.

Centering. Provide and fix all centering and turning pieces requisite in any part of the works; no part of which must be struck until the architect's sanction has been obtained.

Floors. Construct the floors with spruce timbers 15 inches from centre to centre, and to be scantlings figured in the drawings.

Bridging to floors. The whole of the floors to have two rows of 1-inch bridging, and to be the same depth as the joists, and to be well nailed.

Trimmer joists. All trimmer joists to be 1 inch thicker than the rest.

Roof timbers. To construct the roof with spruce timbers, as shown upon the drawings, and of the following scantlings, viz. :—

Ridge-piece,	8	by	¼
Common rafters (every 15 inches from centre to centre),	4	„	2
Purlins,	8	„	4
Struts,	4	„	3
Binders,	8	„	4
Wall-plates,	4½	„	3
Ceiling-joists,	4	„	2
Valley pieces,	9	„	3

Wall-plates. The wall-plates to be in long lengths, well halved and spiked at each joint.

Rafters. All the exposed parts of the common rafters to the eaves, gables, &c., are to be wrought where they project beyond the external face of the walls.

Common rafters. The common rafters are to be securely spiked to the first piece, and upon the purlins, and knotched down and spiked upon the wall-plates at the foot, and trimmed where necessary, or wherever trimming may be required.

Purlins. The purlins are to be closely fitted to the valley-pieces, and to be firmly spiked thereto.

Plant in the front spar to each gable a mould 4 inches deep.

Cantilivers. Provide, work, and fix to all gables, as shown upon the drawings, cantilivers resting on stone blocks or corbels.

Finial. Provide and fix a moulded finial to each gable.

Valley boarding. Provide and fix all valley boarding 7 inches wide.

Bracketing. Provide and fix all needful bracketing and furring down as may be required by the plasterer.

All hearths are to be mitred round and boxed to receive the flag-hearths.

Floors. Provide and lay the floors on the ground-floor with 1-inch spruce deal floor-boards, cut 4½ inches wide, of the best quality, and to be laid with straight joints and splayed headings, made in all cases upon the joints, and to be double nailed, punched, puttied, and neatly dressed off as may be directed.

Provide and lay the floors of the chamber-floor with 1-inch spruce deal floor-boards, cut 6 inches wide, of the best quality, and to be laid as before.

Provide and fix to all gables and eaves of building ¾-inch eaves boarding, wrought on the underside.

Roof. To construct the roof over the bay window with common rafters 3 × 2½, and to have wall-plates 4½ × 3, well dovetailed, and nailed at the angles.

Windows. Provide and fix in the openings to cellar window, and the whole of the windows on ground and chamber floors, 2-inch moulded red deal sashes, double hung (except the two side lights to the bay and Venetian windows, which are to be fixed), fixed into red deal cased frames, with red deal sunk and weathered sills, each pair of sashes to be hung, iron axle pulleys, iron weights, and the best white lines, and fastened with sash fasteners of the value hereafter specified.

Windows. Fit up the windows in dining and drawing-room with 1¼ inch framed and moulded folding shutters, 6 feet high, hung with butt and back-lap hinges, and 1¼ inch framed back flaps, hung into boxing, 1¼ inch fast framing over shutters to correspond with the shutters when placed back; 1¼ inch framed and moulded window backs and square plinth; 6-inch moulded architrave round resting upon coved blocks. Provide and fix upon the shutters to each window a strong wrought-iron spring shutter-bar fastener, each front shutter to have a knob of furniture to suit, and to have such fastener of the value of 1s. 6d. each.

Windows. The kitchen window to be fitted up with shutters as described above, with 5-inch architraves resting upon 1-inch rounded window bottom, and single moulds under, with shutter-bar fastener and sash fastener, value 1s. each.

Windows. The windows in scullery and pantry to be finished inside with ¾-inch casings, single moulds round stopping, upon 1-inch rounded window bottom, and sash fasteners, value 9d. each.

Windows. The whole of the windows on chamber floor to be finished inside with 1-inch casings, 6-inch moulded architraves stopping on 1-inch rounded window-bottoms, with single moulds underneath, with sash fasteners, value 1s. 3d. each. Bedroom windows over dining and drawing rooms to have ¼-inch framed and single moulded window backs and square plinth.

Finish round the cellar window with sailed fillets, and 1-inch rounded window bottom, and sash fastener, value 9d.

Doors. Provide for the front entrance doorway 1¾-inch and double moulded four-panelled red deal door, with moulded transoms, and 1¾-inch segmented fan-light over; the door to be hung with three 3½-inch butt hinges to a red deal frame 4½ × 3, rebated with segmental head, and finished round on the inside with 6-inch moulded architraves resting on coved blocks. The door to be fastened with an 8-inch drawback lock, iron night-chain, and two 9-inch brass flush-bolts and knob.

Doors. The dining and drawing rooms to be 1½-inch framed and double-moulded four-panelled doors, each door to be hung with a pair of 3-inch butt hinges to 1½-inch door casings; finish round on both sides with 6-inch moulded architraves resting upon coved blocks; put upon each door a mortice-lock and white porcelain furniture, value 6s. each.

The closet door in dining-room to be same as above, but single-moulded. The kitchen and scullery to be 1½-inch framed and double-moulded four-panelled doors, hung with a pair of 3-inch butt hinges to 1½-inch door casings; finish round on side facing passage with 6-inch moulded architraves, and single moulds on the other, resting on coved blocks; put upon the doors a lock, with brass furniture, value 4s. each.

Doors. The cellar and pantry to be 1-inch ledged and battened doors, hung on 2½-inch butt hinges to 1¼-inch casings; finish round on both sides of pantry door with single moulds; put upon these doors a thumb-latch, value 9d. each.

Doors. The whole of the doors on the chamber floor to be 1½-inch framed and double four-panelled doors, hung with a pair of 3-inch butt hinges to 1½-inch casings; finish round on both sides with 6-inch mouldep architraves resting on coved blocks; put upon these doors a 6-inch mortice-lock, with cocoa furniture, value 5s. each. The closet door in bed-room over dining-room to be single-moulded.

Keys to doors. No key about the building will be allowed to open more than one lock.

Staircase The staircase to be constructed with 1¼-inch clean yellow pine treads, with moulded nosings; 1-inch yellow pine risers, of the length, rise, and treads, as are shown upon the drawings, with cut bracketted ends, each step to be well blocked and glued up, and to have two spring-trees 7 × 4, and carriages; the steps to be housed into moulded notch-boards, moulded string-bands, 1¼ × 1¼, wrought and chamfered deal balusters, with an iron one every fourth step. Spanish mahogany hand-rail 3½ by 2½; ornamented mahogany newel and scroll, French polished; 1½-

inch framed and single-moulded spandrail, enclosing cellar steps with skirting 7 inches deep.

Provide and fix to cellar steps a plain oak hand-rail 3 × 3, and newel 4 × 4.

Shelving. Provide and fix, when and where shall be directed, 40 lineal yards of 1-inch deal shelving, 12 inches wide, and bearers.

Hook-rail. Provide and fix 20 lineal yards of braided hook-rail, filled in with brass hooks as shall be directed.

Meat-hooks. To provide and fix in cellar six turned meat-hooks.

Bell-board. Provide and fix in kitchen a beaded bell-board 12 inches deep.

Screen door. The screen-door in entrance-hall to be 1½-inch framed and single-moulded sash-door, the upper panels prepared for glazing, with fanlight frame above; finish round on both sides with 6-inch architraves, stopping on coved blocks, 1½-inch casings, with hinges, lock and furniture complete.

Wardrobe. Provide and fix to wardrobe in bed-room over dining-room 1¼-inch framed and single-moulded sliding-doors above and below, and filled in with 1-inch deal shelves and divisions with pullies, cupboard fasteners, &c., complete.

Closets. The closets in dining-room and bed-room above to be filled in with 1-inch deal shelves and divisions.

Staff-beads. To provide and fix ¾-inch staff beads to all angles requiring them, securely fixed to plugs.

Skirting. Provide and fix to the dining and drawing room 1¼-inch double base skirting, 14 inches deep, securely fixed to grounds.

Provide and fix to entrance-hall and landing 1-inch moulded skirting, 12 inches deep, securely fixed to grounds.

Provide and fix to the rest of the rooms throughout, where not specified, with 6-inch truss skirting, securely fixed to plugs.

Water-closet. The water-closet to be fitted up with 1¼-inch deal seat, fixed upon a stillage 3 × 2, with hole cut in the seat; 1¼-inch deal-clamped fall, with moulded nosing and frames, the fall to be hung with 2½-inch butt hinges, and to have 1¼-inch framed and moulded riser, and to put round the seat framed back and elbows, 12 inches high, with rounded copping 1½ × ½ inch thereto.

To all attendance upon the plumber and other tradesmen throughout, finding all materials required.

Cistern to W.C. Provide and fix a supply-cistern above W.-C., formed of 1-inch rough boards, supported on strong beam, the front and soffit to be framed with 1¼-inch single-moulded framing, made for easy access to the cistern.

Casing of pipes. Provide and case up all pipes throughout the building requiring the same.

Boiler lid. To provide and fix to the boiler in scullery a double-boarded boiler-lid, with handle thereto.

Rods and drawing boards. To provide all boards for the various drawings, and rods for setting out the work.

Blocks, bearers, &c., for plastering. To provide and fix all the requisite blocks, linings, furrings, and bearers, for the plastering, and to perform any other work and labour that may be found requisite at the proper performance and thorough completion of the house.

Making good of defective work. Should any part of the work give way or shrink within three months after completion of the building, the same is to be made good by the contractor, for which purpose the sum of twenty pounds will be retained in hand from the contract to make good any defective work which may by that time show itself; and should the contractor neglect to amend or repair any such defective work after two days' notice in writing to that effect, then the proprietor shall be empowered to employ any other person or persons he may think fit to alter the said work, and deduct the expenses incurred thereby from the said sum of twenty pounds.

BELLHANGER.

Bells. To provide and fix to the front entrance door a lever-pull, sunk and bronzed, value 7s. 6d., with a bell to ring in the kitchen.

To provide and fix on each side of the fire-places to the dining and drawing rooms dado-lever pulls, value 3s. 6d. each, with a bell to each room to ring in the kitchen.

To provide and fix to the side entrance door a bronzed lever pull, value 5s.

To provide and fix to three of the bed-rooms dado-lever pulls, value 3s. 6d. each, with a bell to each room to ring in the kitchen.

All the bells are to be of good quality, and fitted up with strong copper wire, plates, cranks, zinc tubes, and mouth-pieces, and to be completed in the best possible manner.

N.B.—The bell-board and bells to be fixed over the scullery door in back passage, and not in the kitchen as above specified.

SLATERS' WORK.

Slates. The contractor to provide and cover in the whole of the roofs with the best quality of Vallinelli slates 22 × 12, laid with a lap not less than 3½ inches, and securely fixed with two iron galvanized nails to each slate, weight 170 to 1 lb. upon Quebec yellow pine battens 1½ × ¾, and nailed at the requisite distances apart with 1½-inch rose-headed nails, and well point the same with strong hair mortar.

Ridge tiles To provide and cover the whole of the ridges of roof with blue Staffordshire lap-jointed ridge-tiles, and to be well bedded and pointed with black mortar.

Double slates at the eaves. The whole of the roofs are to have a double row of slates along the eaves.

PLUMBING AND GLAZING.

Gutters. To provide and lay the gutters with 5 lb. lead, averaging 24 inches wide.

Valleys. To provide and lay the valleys with 5 lb. lead, averaging 15 inches wide.

Flashing. To flash the chimneys and roofs over bay and Venetian windows, or wherever flashing is required, with 14 lb. lead, 10 inches wide.

Cistern. Line the supply-cistern over W.-C. with 5 lb. milled lead, to be neatly laid, dressed, lapped, and soldered, 3 ft. 6 in. × 2 ft. × 2 in. deep, with 1-inch water supply-pipe, Lambert's ball-cock, &c., complete.

Provide and fix to the cistern a 2-inch lead overflow-pipe out of 4 lb. lead, and provide and fix thereto a 2-inch brass plug-washer and waste, with trumpet-topped head.

W.C. Apparatus. To provide, and fix complete, a water-closet apparatus, with iron pan, with blue and white basin, "S-trap," 5-inch soil-pipe out of 5 lb. lead, well seamed to the walls, and provide the requisite 3¼-inch lead service-pipe from the water-cistern to the pan-chest complete, with service-box and pipe, and all requisite cranks, brass wires, and other fittings of the most complete description, and leave the same in perfect working order.

Slop-stone. To provide and fix to the slop-stone in scullery a brass bell stench-trap, and 1½-inch lead waste-pipe to carry the waste water to drain.

Eaves. Provide and fix to the eaves of roofs a cast-iron moulded eaves-gutter, ¼ metal, to be firmly secured to the ends of spars, with all chips, heads, shoes, &c., complete.

Rain water pipes. To convey the water from the roof, as they are shown upon the drawings, down to the eyes of the sewers, with 3-inch cast-iron pipes, $3\frac{1}{16}$ metal, with all the requisite heads, shoes, and clips complete.

Venetian window roof. Provide and cover the roof of Venetian window with 4 lb. milled lead.

Gas piping Provide and lay to the whole of the bed-rooms on chamber floor, landing, staircase, entrance-hall, dining and drawing rooms, kitchen, scullery, and back passage, with gas piping, ¼-inch bore, and as shall be directed, finding all bends, junctions, &c., complete, and leave the same ready for the reception of the gas fixtures, which will be found by the proprietor.

Glazing. The cellar, scullery, pantry, bed-room over, and water-closet windows, to be glazed with the best crown glass, 16 oz. quality.

The rest of the windows to be glazed with Chance's 21 oz. sheet glass.

The screen-door, and fanlight above, in entrance-hall, to be glazed with Forest glass, with coloured ornamental patterns, price 1s. 6d. per foot, nett. The staircase window to be glazed with Forest ornamental-coloured glass, with plain-coloured margins, orange, blue, and red, with stars upon red or blue ground.

All the glazing to be well bedded and back-puttied, and to be as free as possible from air-bubbles, colour, or any other defects, and is to be left perfect and complete at the final rendering up of the building, without any additional charge.

PLASTERING AND PAINTING.

Laths. The whole of the laths are to be of a good quality, of strong Dantzic fir heart-laths, and to be well nailed to the floor-joists.

Mortar. The mortar to be composed of fresh-burnt ——— lime and sharp clean sand, mixed in the proportions of one-third of lime to two-thirds of sand, mixed under cover, in such quantities as may be directed, with a sufficiency of long-piled English hair therein.

Lime. The lime to be run three weeks previous to being used, and to be kept free from mud or dirt.

Ceilings. The whole of the ceilings and studded partitions are to be properly laid to receive the plastering, so as to form a good key.

The cellar ceiling to be lathed and plastered one coat, and skimmed, and the walls and ceilings to be twice lime-washed. The ceilings of dining and drawing rooms, entrance hall, staircase, and landing, are to be lathed and plastered three coats smooth stucco, finished grey, and twice whitewashed.

The rest of the ceilings to be lathed and plastered two coats, and twice whitewashed.

Walls. The whole of the walls on ground and chamber floors are to be plastered two coats, with all the angles neatly floated down.

Cornices Run plaster cornices to the dining and drawing rooms 18 inches girth.

Run plain plaster cornices to entrance hall, porch, staircase, and landing, 9 inches girth. The back passage, scullery, and pantry, to have 6-inch Portland cement skirtings.

Pointing. To bed and point all the doors and windows with strong hair mortar.

To point the whole of the interior and exterior wood and iron work, usually painted four good coats of pure oil paint, mixed in strong bodies. To knot, stop, and pumice down the work previous to painting.

The contractor is to provide all drainage materials and workmanship, finding all scaffolding, trowels, ropes, planks, wheelbarrows, ladders, and all other tackling tools, moulds, rulers, templates, and every other matter or thing of whatever description necessary or required for the due and proper execution of the whole of the works, and leaving the same whole, perfect, and complete, at the finishing of the building.

10. We now give examples of specifications adapted for farm-buildings. The first in par. 11 is one for the farm-buildings, the plan of which is given in fig. 5, and the description in par. 29 of Essay Tenth, on "Outlines of Agricultural Architecture," and may be taken as an example of the Scotch method of drawing up a specification for a building in stone, with the Scotch technicalities. We take this specification from the number (34) of the Transactions of the Highland and Agricultural Society of Scotland, in which the drawings and details are given. The second specification in par. 12 we have drawn specially up to illustrate the requirements of a structure in which brick is employed, such as is used in England, with the English trade technicalities. For the purposes of reference we have added to these specifications marginal notes, as recommended in a previous paragraph. This specification may be taken as adapted to the farm building illustrated in fig. 7, par. 30, p. 6, of Essay Tenth. But the details and fittings are obviously applicable to all farm structures of brick.

11. Specification of the works to be done in the erection of the farm-buildings illustrated in fig. 5, Essay Tenth.

Tiles and collar drains. DRAINAGE.—After the site of the buildings has been marked off, and the surface-mould removed therefrom, the next point to be considered is a complete subsoil and surface drainage, done with tiles and collars, in the direction most suitable for carrying off the surface water from the rooms and channels round the buildings.

Depth of tracks for foundations. EXCAVATIONS.—The tracks for the foundations of walls to be dug out to a depth of not less than 20 inches below the original surface of the ground adjoining; and if at that depth a firm and sure substance to found upon is not obtained, the digging to be continued to whatever depth shall be found necessary for that purpose; but in all cases where the tracks are not upon the same uniform level, and one part of them is deeper than another, each separate part or parts shall be a dead level of itself, so that no inclined plain shall be found in the whole range of the foundations.

Depth of excavations for floors. The excavations for the different floors shall be made so that they may range 3 inches above the centre of clean court, 24 inches above the centres, and 3 inches above the sides of cattle courts, and 9 inches above the adjoining surface outside of buildings, exclusive of the thickness required for pavement, causeway, metalling, and composition. The floors for box-feeding byre to be dug out to the same level as the centre of cattle-courts, and the urine-tanks and dung-pits to the depth shown on the section.

Removal of soil. All the soil and subsoil arising from the above excavations to be removed and laid down as shall be directed by the architect, the distance not to exceed 50 yards from the site of the buildings in any direction.

Founds of wall. MASON WORK—RUBBLE BUILDING.—The wall to be founded with large flat-bedded stones, of the several forms and dimensions delineated in the drawings, and to be at least 8 inches thicker than the wall immediately above, so that a scarcement of 4 inches may be formed on each side. *Stones of walls.* The walls to consist of good rubble-stones and lime-mortar in proper proportion; the stones laid on their natural and broadest beds, with hand-stones laid through the walls at short distances.

Division walls in byres. The division-walls between byres to be carried up to the height of side walls only, and all the other division-walls to be carried up to the ridge. The walls of corn-barn, straw-barn, boiling-house, and riding-stables, to be beam-filled to the sarking.

Enclosing walls of cattle courts. The walls enclosing cattle-courts to be 20 and 13 inches thick at bottom and top, and 5 feet high above the surface, exclusive of a 10-inch high semicircular hammer-dressed cope.

Walls in feeding-byres. The feeding-cribs in box-feeding byre to rest on a 2-feet thick rubble-stone and lime-mortar wall, raised up to the height shown on the section.

Walls of dung-pit. The walls on each side of dung-pits to be 14 inches thick at top, and increased in thickness downward 2 inches for every foot in height, and finished on the top with a flat hammer-dressed cope, of 18 inches broad by 6 inches thick, projecting 2 inches over the wall on each side.

Engine-stalk. BRICK-WORK.—The engine-stalk, to the height of side walls of corn-barn loft, to be carried up with stones and lime-mortar, and above that to the height of 35 feet, exclusive of hewn ashler projections, to be built with circular bricks in the order of a Corinthian column. *Flues.* The necessary flues, and 10 feet up the inside of engine-stalk, to be lined with fire-clay bricks. The division-walls between boiler and engine-house to be built with bricks on bed. *Engine-tank.* The engine-tank to be 6 feet diameter inside by 15 feet deep below the surface, built with circular bricks on bed, and arched over on the top, reserving a 20-inch square hatch in the centre, closed up with a 4½-inch thick pavement, with an iron ring in the centre. Where it is supplied only from surface-water, the outside of walls to be puddled 4 inches thick to prevent leakage.

Urine-tank. The urine-tanks to be built with bricks in length, and arched over in the centre, reserving also a hatch 20 inches square, and shut with pavement. This tank to be furnished with Roman cement inside, and puddled on the bottom and outside of walls to prevent the urine mixing with mineral water.

Rybets, sills, lintels. HEWN MASONRY.—The rybets, sills, and lintels, and arches of doors, windows, and other voids, to have droved margin and ingoings 5 inches broad each, and broached on the tails, the sills of windows to be made to project 2 inches over the walls. The gig-house, potato-house, turnip-house, and box-feeding byre side door to corn-loft, and shed-boles, to be finished with giblet-cheeks.

Gate pillars. The gate-pillars, pillars, and arches of cart-shed, scuntions of cattle-sheds, chimney-heads, and all external corners, to be droved 4 inches, girt on the angles, and broached on the faces. The angles of pillars, scuntions of doors, rybets to be chamfered, the site of the engine to consist of two large stones, 3 feet square each by 10 inches thick, and to be laid and finished as directed by the engineer.

Mouldings of engine chimney. The base and top projections of engine-stalk to be droved; the block on the top to be hooped 6 inches broad, with 36-oz. zinc.

Skews. The skews to be 15 inches broad and 3½ inches thick, neatly droved; 2½ inches of this breadth to be made to project over the walls.

Travises. The division-stones in stall-byres to be 5 feet square and 4½ inches thick, droved Arbroath pavement, rounded on the angles, firmly dwanged with the feeding-cribs, *Travises in byres.* the sides and soles of which, in this byre, shall be constructed with droved Arbroath pavement, 4½ inches thick, 13 and 16 inches broad bottom and top, by 10 inches deep inside.

Pillars in implement house. The cast-metal pillars in implement-house to rest on 16-inch square stone blocks, set down flat with the surface.

Urine Channels. The urine-channels in stall-byres to have droved cribs and soles, each 5 inches thick; the crib next the cattle to be 8 inches, and that on the other side 4 inches deep, and placed 14 inches apart; the sole of crib to have perforated cast-metal grating every 14 feet in length, and laid to suit the purpose of cover for a box-built drain below, 10 by 8 inches inside. The urine from these channels to be carried off into the tanks and dung-pits through a glazed pipe tile, 4½ inches diameter, with regular valve for shutting or opening the flow of urine into the tanks or dung-pits as may be required.

Pig troughs. The troughs for piggeries to be droved freestone, hollowed out, 15 by 12 inches, and 10 inches deep. The channel in riding-horse stable to be droved freestone, 18 inches broad, and hollowed out in the centre.

Stone blocks for travises. The stone blocks for travis-posts in stables to be 18 inches deep by 15 inches square; 15 inches of this depth to be set down below the causeway, and the remaining 3 inches above to be hollowed out in the centre for receiving the posts, and the angle to be chamfered off to meet the causeway.

Cooler. The cooler for boiling-house to be 7 feet long, 4 feet broad, and 20 inches deep inside, constructed with droved Arbroath pavement 3 inches thick.

Hen-house. The hen-house to have two rows of nests, constructed with 2½-inch droved Arbroath pavement, the one row to be 4 inches, and the other row to be 4 feet, above the floor; the sole of upper row to project 5 inches over the walls.

Floors of corn-barn, &c. *Skirting.* *Pavement of straw-barn.*

PAVEMENT.—The floors of corn-barn, engine-house, boiling-house, hen-house, bruising-house, to be laid with droved 2½-inch thick Arbroath or Caithness pavement, closely jointed, and laid solid on a bed of engine ashes or lime riddlings; these floors to be finished with droved pavement skirting, 7½ inches deep and 1½-inch thick, 1½ inch of this depth to be set down between the flooring and the wall, and the remaining 6 inches above the floor to be chamfered off to meet the plaster. 17 by 10 feet of the floor of straw-barn in front of the straw-rack, 12 feet square in front of door to corn-barn loft in stack-yard, to be laid with rough, closely-jointed, 2-inch thick Caithness pavement, on a bed of lime riddlings or engine ashes.

Floors of byres.

CAUSEWAY.—The floors of byres, railway passages, dung-pits, passages between dung-pits and byres, tool-house, piggeries, stables, loose-house, infirmary, and 3-feet channels, round clean court and passages, to be laid with good rubble whinstone causeway, the stones not to be less than 7 inches deep, and not more than 12 square inches on the top, and bedded in good sharp sand.

Composition floors.

COMPOSITION.—The floors of straw-barn, cut-straw shed, and potato-house, to be laid with a composition of engine ashes, lime riddling, and ox blood, made into mortar, and laid on 3 inches thick, and closely rubbed down till dry.

Court metalling.

METALLING.—The clean court and passage within channels, 20 feet broad in front of offices, and road leading to stack-yard, to be laid with small broken whinstones, 6 inches thick.

Drain in feeding-byre.

A box-built drain, 8 by 6 inches inside, connected with the urine-tanks, to be laid along the centre passage of the box-feeding byre; this drain to be 3 inches diameter, and to communicate by a pipe and grating with each box, for carrying away any unnecessary damp below the cattle.

Lintels.

JOINER WORK—SAFE-LINTELS.—The safe-lintel over doors, windows, and other voids, to be of sufficient breadth, and 1 inch thick for every foot of opening they cover, with a wall-hold of 9 inches at each end.

Beams.

BEAMS.—The granary to have beams, 12 by 6 inches, resting on the front pillars and back wall, with 12 inches of wall-hold at each end.

Shakers of thrashing machine.

The drum-shakers to be supported on two beams, 12 by 6 inches, and one beam, 16 by 8 inches, fitted up and finished under the direction of the millwright. The beams for cattle and implement sheds to be 6 by 18 inches, cleaned off on the outface, and beaded on the under angle, with 10 inches of wall-hold at each end.

Scantling of timbers.

ROOFING.—The roofing to have scantling 6½ by 5½ inches broad, bottom and top, by 2¼ inches thick, and placed 20 inches between centres, with baulks, 5½ by 2 inches, placed two-thirds below the top, and wall-plates, 8½ by 1¼ inches.

Ridge.

The sarking to be ¾-inch thick, closely nailed together; that over the granary and bruising-house to be half checked. The ridge and peind battens to be 1½ inch diameter, firmly fixed with strong iron studs.

Ventilators.

VENTILATORS.—Ventilators to be made in the roofs of stables, byres, calf-house, loose-house, infirmary, and boiler-house, with galvanised sheet-iron, or boards clad over with zinc, similar to those used for railway sheds, with this difference, a bead to be made on the top, in imitation of the other part of the ridge.

Barn joists.

JOISTING.—The joisting for corn-barn, straw-barn, and hay-house lofts, to be 10½ by 2 inches, placed 20 inches between centres, with 9 inches of wall-hold at each end, and one row of dwanges along the centre, 6 by 2 inches.

Granary joists.

The joisting for granary, bruising-house, and stable beds, to be 7 by 2½ inches, and placed 20 inches between centres, with 9 inches of wall-hold at each end.

Barn floors, &c.

FLOORING.—The flooring for lofts of barns, granary, horse corn-loft, stable beds, to be 1¼ inch thick, grooved and tongued; that for stable loft to be 1½ inch thick, resting on the run-beams at each end. The skirting for deal flooring to be 3 by 2 inches, nailed on the flooring, and chamfered off on the top angle to meet the plaster.

Doors to sheds. *Doors to Stables.*

DOORS, BOLES, &C.—The door and bole boards for sheds to be plain deal, 1¼ inch thick, grooved and tongued, the deals not to exceed 3 inches broad, and beaded on the edge of the joints with three back-bars on each door, and two on each bole-board, 6 by 1½ inches. The doors on gig-house, potato-house, turnip-house, corn-barn loft, and four doors on stables, to be hung in two halves; the doors on loose-house, infirmary, and calf-houses, to be also in two halves, cut across the centre; the piggery door to have vertical sliding frames, to lift out if required.

Standards.

The division-wall doors to have standards 4½ by 2 inches, and keps 3 inches by ⅝ths of an inch, firmly fixed with dooks built into the wall.

Ground floor windows. *Skylights.*

WINDOWS.—The windows on ground floor to be fitted up two-thirds, and those in upper floor one-third below the top, with second crown glass; the other portions to be fitted up with vertical storm-boards. The different skylights to be glazed with second crown glass in cast-iron frames; and that above rollers in corn-barn loft to open on hinges on a raised frame; the soles of windows to be clad with ¾-inch plain deals.

HATCH-BOARDS.—The hatch-boards in straw-barn loft floor, and granary floor, the former to be 5 by 2¼ feet, and the latter to be 40 inches square, each to have two back bars, 6½ by 1¼ inch.

STAIRS.—The stairs in bruising-house and harness-room to be constructed with steps and standards of sufficient strength.

Run-beams. *Head and heel posts.*

STABLE TRAVISES.—The stable to have tie-beams, 6½ by 2½ inches, directly above each travis-board, firmly nailed to the bottom of the scantling at each end. The run-beam, 6½ by 2 inches, to run parallel with the side walls of stable, and to be nailed down on the top of the head and heel-posts, and also checked into the tie-beams above. The head and heel posts to be 6½ inches square each, rounded on the angles. The travis-boards to be 1½ inch thick, iron doweled on the joints.

Travis-boards.

The travis-boards to be firmly fixed into the posts in the usual way, with sole and coping of oak, 3½ inches square each, grooved half-inch deep, for receiving the boards, rounded on the angles, and firmly fixed into the posts at each end.

Hay-racks

The hay-racks to be 2¼ inches broad over the rails, and to be securely fixed up to a height and slope, as shall be determined by the architect.

Mangers.

The mangers in large stables to be 2¼ feet long, 15 and 10 inches broad top and bottom inside; the remaining space of stall to be fitted up with grass-racks the height of manger, and finished with an oak rail 6 by 4 inches along the front of mangers, and under racks, and rounded on the angles.

Riding-stable mangers. *Stable brackets.*

The riding-stable to be fitted up in the same manner, except that there are to be no grass-racks, and the mangers are to be 6 feet long, 14 and 9 inches broad top and bottom, with oak rail, 6 by 4 inches, along the front of manger, and rounded on the angles. Each stable to have sufficient brackets and harness-pins built into the walls.

Corn chests.

The corn-chests in horse-corn loft to be each 3 by 2 feet at bottom, and 5 by 3 feet at top, by 4 feet deep inside; these chests to have each a wooden pipe conductor, 4 by 2 inches, leading through the wall into the harness-room. The under end of this pipe to have two sliders, fixed at such a distance apart as that the vacuum formed shall be equal to the size of a common feeding measure; the principle of the construction of this apparatus will be provided by the architect.

Corn-chest in riding stable.

The corn-chest in riding-stable to be fixed and fitted up in the bossing of the window sufficient to hold one boll of oats.

Feeding-cribs. *Railway passage.* *Partition.* *Pig-troughs.*

BOX-FEEDING BYRE PARTITIONING.—The feeding-cribs, or box-feeding byre, to be cast metal, 3¾ feet long each, 16 and 20 inches broad bottom and top, by 10 inches deep each. The space left in the centre between boxes to be fitted up with straw-racks, 3½ by 2 feet, and 3 feet high above the soles of feeding-cribs, and sparred all round. The partitions in box-feeding byre to have two posts, 5 inches square, for each single division, the one placed in the rubble wall by the side of centre railway passage, and the other betwixt that and side wall, both carried up within 2 inches of the height of side walls, and fixed on the top with 7 by 2½-inch tie-beams, and 5 by 2-inch run-beams, in the same manner as those specified for stable. Each partition to have four rails, 5 by 2 inches, placed 12 inches apart, firmly fixed into the above posts at each end. All the byres to have an iron rail, 1¼ inch diameter, fixed 20 inches above, and directly over the outer edge of feeding-cribs, with swing-boards attached, 1¼ inch thick, hung from the top, so that by pressing the board back below the cribs may be cleaned out, and filled with turnips, without disturbing the cattle. The same principle of boards to be applied to the piggery-troughs. The iron bars in box-feeding byre to pass through centre of a 5-inch square upright post in the centre, and also at each division.

RAILWAY SLEEPERS.—The sleepers for railway to be 4½ by 2½ inches, placed 3 feet apart, and laid on a solid substance.

Gates. *Gate-posts* *Stiles.* *Rails.*

The five gates required for courts to be hung with 8½-inch square wooden posts, placed flush with the outside of pillars, so that they may open outwards conveniently. These posts to be built 20 inches into the ground with stones and lime mortar, and to stand 6 feet above the surface. Each gate to have 6 by 4 inches hanging stiles, 5½ by 3¾ inches centre stiles, and 5 by 3½ inches front stiles, with rails each, 5 and 4½ inches broad, by 1⅜ inch thick. Each rail to pass through the centre stile, and to be mortised into the other two stiles at each end. The two under rails to have vertical dwarf spars, 2¼ by 1 inch, 18 inches high, and placed 2½ inches apart. The small gate in passage to south cattle-court to be the size and description of half one of the large gates.

Timber to be used.

All the wood used, except the oak already specified in stable, to be of the best Memel timber; the deal flooring may be of drum battens; but all the timber of every description to be of the best quality, free of sap-wood, loose and large knots, and other blemishes.

Feeding cribs. *Cast-iron pillars.* *Crooks and bands.* *Hinges.* *Back bars.* *Rings and staples.*

Iron Work.—The cast-iron feeding-cribs for box-feeding byre to be the size given in the joiner work, cast ⅞ths of an inch thick, with 2½ inches broad flanges round the top. The rails to be 2 by 1 inch malleable iron, fixed on the sleepers with spike-nails. The pillars for implement-shed to be cast-iron, 4½ inches diameter, with plate at top, 12 by 1 inch, with sockets for pillars, and holes for nailing the plate to the beams. All the outside doors to have strong crooks and bands, the crooks to be 8 inches long, with split tails, and firmly fixed in the rybets. The division wall-doors to be hung from strong T hinges. Twenty-six doors to have strong stock-locks, and fourteen of that number to have folding keys and sunk ring latches; all the other doors and boards to be secured with strong iron back-bars. The gates to be secured with iron hasp, chain, and pin, and gates and hatch-boards to be hung from strong crooks and bands. The swinging-boards above byre feeding-cribs to be hung from 1¼ inch diameter iron rod; in the one byre the rod is to pass through the 5-inch square posts, and in the other byre it is to pass through the division-stones 20 inches above the feeding-cribs. The cattle in stall-byre to be secured with run rods and chains fixed to the division-stones. Each stall in stable to have two rings and staples for securing the horses.

Padlocks.

The corn-chests and hatch-board in granary to be secured with strong padlocks; all the iron-work to be of Scotch manufacture.

Lathes.

Lather's Work.—The ceilings of boiling-house, riding-stable, engine-house, and stable-bed lofts, to be lathed with good split lath.

Ceilings.

Plasterer's Work.—The ceiling and walls of boiling-house, riding-stable, engine-house, and walls of corn-barn and loft, bruising-house, and loft, granary, horse corn-loft, men's bed-loft, stables, and harness-room, to get two coats of good hair-lime plaster.

Ridges. *Lead pipes.*

Plumber's Work.—The ridges and peinds to be covered with 5 lb. lead, the flanks and flashings round the skylight and gutters with 6 lb. lead. The pump at boiling-house door to be cast metal, with lead pipe 1¼ inch attached to the boiler and feeding-cribs in byres, with soil-pipe from the feeding-cribs to the nearest drain.

Roans.

The roofs to have 20 oz. zinc roans and iron upright conducting pipes, with sufficient iron straps.

Painter's Work.—All the external doors, windows, and wood work of every description, to get three coats of the best oil paint.

We draw the particular attention of the reader to the above specification, as containing a large amount of information in connection with the fittings of farm buildings. Many of these, specially designed by Mr. Bell, are distinguished by ingenuity and simplicity.

12. Specification of the works to be done in erecting farm-buildings, of which a sketch of ground plan is shown in fig. 7, par. 30, p. 6, of Essay Tenth, in this work, adapted also to the prize steading described in par. 24, Essay Tenth, and of which full plans, sections, and elevations, will be found in vol. XI. of the Journal of the Royal Agricultural Society of England.

EXCAVATOR.

Trenches. Excavations for Tanks.

Dig the trenches to the dimensions as shown in plan of foundations; the excavations for drains, dung-pits, tanks, &c. The earth to be well rammed up to the walls as the walls are carried up. A course of concrete to be laid under the footings of external walls of the apartments designed for live stock; in order to prevent damp rising, the depth of such course of concrete to be not less than 18 inches; and to be thrown into the trenches from a height of at least six feet in order to well consolidate it. The surface of all yards and floors to be levelled, and all loose earth to be removed to a convenient distance, and laid down in position shown by proprietor.

BRICKLAYER.

Mortar. *Walls in brick.* *Relieving arches.* *Bull-nosed bricks.*

All the walls to be carried up with good, hard, well-burnt stock bricks, laid in mortar, made of three parts of good lime, and one part of clean sharp sand. The walls to be carried up in old English bond; and no four courses of brick to be raised more than three quarters of an inch above the collected height of the bricks. To prevent damp rising lay a course of slates, laid in tar or cement, all round the walls at ground-level. The external joints of the brickwork to be finished off with a neat rule joint, with white or black cement according to taste of proprietor. The inside joints to be left rough in those apartments the walls of which are to be plastered; to be finished with a neat rule joint in white, where no plastering is to be done. Relieving arches in 9 inch work to be turned over all voids or openings. All bond timber, &c., used in the work to be bedded in mortar; and all window and door frames to be pointed round with hair mortar. All the corners of doors to cattle-houses and boxes to be made with bull nosed or splayed bricks, to prevent injury to be done to the stock in passing in and out.

Tanks. *Retaining walls.* *Footings.* *Troughs. Cisterns.*

The liquid manure tanks to be arched at crown and invert with quick brickwork cement, and to be provided with an 18-inch manhole in centre of crown. Retaining and division walls under wood framing, rails, &c., between walls, or to sustain passages, to be 9 inches thick; the upper course to form a coping, laid edgewise in cement. All piers not more than 2 feet 3 inches by 1 foot 6 inches to be of brick, above ground, upon rubble stone footings, 6 inches broader each way. The footings of one storey walls to be 6 inches, and those of two storey 9 inches broader than the superincumbent work. The flues 14 inch by 9 inches to be pargetted with cow-dung mortar. Chimney bars and all other requisite ironwork, as boilers and gratings for food stores, to be provided. All troughs, cisterns, &c., to be under-built as required. The floors of all the apartments to be made in brickwork on edge, set in cement. The whole of the drains to be in tubular work with capped and lidded junctions. Cesspools in 9-inch brickwork to be built to stables and cow-houses to receive drainings; a trapped tube to lead from each of these to drain tube, leading to manure tank.

Sills. *Blocks.*

Mason.—Stone sills weathered and throated to be provided to all window openings; to have a bearing on the wall on each side of not less than 6 inches. Provide to all doors stone blocks with mortice-holes to receive ends of door framing. Provide dressings to doors and windows, as may be shown in elevations. Provide coping to all walls, gables, required. Provide stone blocks to receive head and tail posts of stables and travises of cow-houses; also blocks for all storey posts and shed pillars as required. The apartments for cooking food to be paved and faced, and jointed in cement. Provide covers for tanks. The mason to cut all holes for iron and wood work where required by and to the satisfaction of the clerk of the works.

Storey posts. *Hook stones.*

All wood storey posts, or supports to roof timbers, to rest upon a stone slab not less than 6 inches thick, fixed firm and level upon the footings, roughly axed and bevelled, and sunk to receive foot of post. Hook stones, with strong hooks sunk and leaded in, to be fixed to all the doors opening externally, except those hung to posts, roughly axed, and projecting 1 inch all round.

Bond timber, &c.

Carpenter and Joiner.—All the timber used to be of the best quality, well seasoned, and free from all knots, sap, or shakes. All necessary centering, lintels, blocking pieces, firing, &c., to be provided to the full scantling shown in drawings. Bond timber, grounds, &c., to be provided. The flooring joists in second storey to be laid on a wall-plate built into wall, securely notched to same, and not be set a greater distance apart than 14 inches from centre to centre. The roofs of wrought-iron as shown in sections in fig. 8, Essay Tenth, and in Plates XXXIV. and XXXV. in this work, and of timber of the following scantlings:—

Scantlings of roof timbers.

Cattle Boxes.

Memel Fir.	Tie-beams in collars,	5 by 4
	Principal rafters,	6 „ 4
	Purlins,	7 „ 4
	Struts,	3 „ 3
	Brestsummers or Plates,	6 „ 4
	Eaves spar,	3 „ 2
	Ridge,	7 „ 1¼

Wrought-iron Straps and Bolts.

Of larch common rafters,	3½ by 2
Of axed elm storey posts,	6 „ 6

Cow Boxes.

Of Memel fir.	Tie beams,	5 by 4	Ridge,	7 by 1
	Principal rafters,	6 „ 4	Eaves spar,	3½ „ 2
	Purlins,	6½ „ 3½	Brestsummers,	6 „ 4
	Struts,	3 „ 3	Plates and pads,	5 „ 3
Of larch common rafters,				3½ „ 2
Of elm storey posts,				6 „ 6

Barn and Dairy.

Memel fir.	Tie beams,	7 by 4	Ridge,	7 by 1¼
	Principal rafters,	4 „ 4	Purlins,	7 „ 4
	King post,	4 „ 4	Plates and pads,	5 „ 3
	Struts,	3 „ 3		
Of larch common rafters,				3½ „ 2

ON SPECIFICATIONS AND ESTIMATES.

Engine House—Hay Loft—Carpenter's and Smith's Shop.

Memel fir.	Tie beams,	6 by 4	Purlins,	6 by 4
	Principal rafters	4 „ 4	Plates,	5 „ 3
	King post,	4 „ 4	Ridge,	7 „ 1¼
	Struts,	3 „ 3		
Of larch common rafters,				3½ „ 2

Horse Boxes.

Memel fir.	Tie beams,	8 by 4	Struts,	3 by 3
	Principal rafters,	4 „ 4	Plates,	5 „ 3
	Purlins,	7 „ 4	Ridge,	7 „ 1¼
Of larch common rafters,				3½ „ 2
Of elm storey posts,				6 „ 6

Pig Boxes.

Memel fir.	Brestsummers,	6 by 4	Ridge,	7 by 1¼
	Plates,	5 „ 3		
Larch—common rafters and diagonal braces,				4 „ 3
Elm storey posts,				6 „ 8

Implement Shed, and Bull and Manure House.

Memel fir.	Brestsummers,	8 by 6
Elm storey posts,		8 „ 8

Sheep Ties.

Memel fir.	Brestsummers,	6 by 4
Elm storey posts,		6 „ 6

Lean-to Sheds.

Memel fir.	Principal rafters,	4 by 4	King posts,	4 by 4
	Tie pieces,	5 „ 4	Struts,	0 „ 0
	Brestsummers,	7 „ 5	Ridge,	0 „ 0
Elm storey posts,				6 „ 6

Barn and Cheese Room.

Poplar.	Girders,	14 by 9	Grand floor joists,	5 by 3
	Joists,	8 „ 3		

Boarded to the extremity of corn bin with one inch rough boards.

Scantlings of floor timbers.

Granary.

Of poplar.	Joists double bridged,	8 by 8	Passage,	6 by 2

Boarded with smoothed 1 inch boards.

Nag Stable.

Of poplar.	Joists single bridged,	6 by 2

Boarded with ¾ inch rough boarding.

The above are the scantlings as given in the specification of the Prize Steading described in par. 24, Essay Tenth, in this work, and which the reader will find in full in Vol. XI. of the "Journal of the Royal Agricultural Society." The following description of mode of fitting up the stock-houses is taken from this specification; it will be found to embody many valuable hints:—

Divisions in cattle-boxes. "The divisions in these boxes to be formed with split rails of larch or ash fixed into the storey posts, three in height as shown; the two upper rails to be capable of being fixed at different heights by means of a stud at one end to enter holes in a post, the other end being secured by an iron pin passing through the end of the rail, and through two fillets nailed on the outer storey-post; an intermediate axed elm post, and one rail in height, to divide off the passage, also morticed into the storey posts; the short post to have a joggled, rough foot, built into retaining wall.

Divisions in cow-boxes. "The divisions in these boxes to be formed as before with split rails and rough elm posts between storey posts.

Divisions in horse-boxes. "The divisions in these boxes to be formed with split horizontal rails, with vertical braces nailed against them as shown, built into the wall at one end, and fixed into storey posts at the other.

"One height of strained iron wire to form divisions from passage, stiffened by an intermediate post sunk into the ground and tarred, 5 × 5.

Divisions in pig-boxes. "The divisions to be formed with rough posts, split rails, and slabs, as shown; each to have a wicket, ledged and braced, hung with hooks and bands and a fastening. The yards to be enclosed and divided in a similar manner, and each having a swing-feeding door, barred, ledged, and braced, hung to a round iron rod, having a long vertical belt with handle fixed in the centre; these doors to swing inwards or outwards, the belt to shoot into a hole in the front of the trough; a 1 inch 1 foot 6 inch wide door, swinging both ways, in the yard division next the covered sties.

Roofs of bull and manure house. "These roofs to be formed with fir pole rafters and collars, and the plates tied together over each storey post and pier with a 1¼ inch iron tension rod, nuts, plates, &c.; each side of manure shed to be closed with 3 moveable split rails in height, dropped into staples.

Roof of sheep ties. "This roof to be formed with fir poles and collars as above, spiked or strapped together.

"The spaces between piers to be closed with split rails or poles built in and stiffened with stakes, the whole then interwoven with faggot or furze. The spaces between storey posts to be filled with ¾ luffer boarding from the height of mangers upwards, with vertical shifting laths, pins, &c., complete.

"Divisions between ties to be ½-inch braced boarding."

Roofs of lean-to sheds. These roofs to be formed with split or round poles to receive thatch. The spaces between piers to be closed with rails built in, stiffened with vertical stakes, and wound as before with furze or faggot.

Timber. The whole of the foregoing memel timbers to be from the saw, and that of larch also, the elm posts dressed with axe only, but the whole firmly framed together with all necessary strops, bolts, or other iron work. All timbers not straight, or partially round, to exceed the dimensions figured; no rafters to exceed one foot apart; all the slated roofs *Rafters.* to be battened with 2½ × ¾ inch battens, and to have diagonal or 1 inch × 5 inch tilting fillet at the eaves. All valleys to have ¾ boarding on proper bearers; *Bearers.* inch poplar stairs with 1¼ strings, hand-rail, and balusters, *Balusters.* to be fixed when shown complete; wood bricks when required, *Wood bricks.* and strong lintels over all openings.

Traps. Traps to be formed and hinged over ladder and fodder rack. The pigeon-house and fowl-roost to be formed with rails and rough boarding close jointed; the floor of straw barn to be covered with wattled hurdles; the whole of the foregoing roof or floor timbers resting upon walls to lie upon 4 × 3 memel bond and pads, laid on bricks in mortar, and all the wall-plates to be connected through gables with the same, or 1 inch × ¼ inch iron strops, clipping the ends of plates.

Doors of cattle-boxes. *Poplar Doors and Boarding, &c.*—The doors of cattle and cow-boxes to be formed with split rails, and ¾-inch rough boarding, 3 inches shorter from the top than opening, and 6 feet wide; these doors to be diagonally braced and hung with 24 inch hooks and bands to the storey posts, each to have an iron hook fastening lifting into a staple, and shutting against the second storey post.

Doors. *Double doors* to be 1 inch rough boarded, 1¼ ledged and braced, hung to hook stones with 16 inch bands, falling against an elm stop sunk 3 feet into the ground, and provided with a staple to receive link at bottom of door; each pair to have a long wrought-iron bolt to shoot into lintel, and an external swing-bar fastening, staples, &c., complete. *Doors.* The remaining doors upon ground plan to be inch ledged, square jointed; those opening externally hung to revealed hook stones with 12 inch hooks and bands; those opening inwards to be hung in 5 × 3 memel frames, built in, and resting upon plinth stones with dowels in foot; those of upper floor the same, except straw doors, which may be ¾ ledged, latch and catch to each.

Horse-box doors to be 1 inch ledged and braced, and suspended upon 1¼ × ½ inch iron rail, with bent strops clipping the top of door and fitted with wheels, the door to open and shut against the pins of suspension rail, and a wood stop built in wall half the height of doors, which slide behind two elm stops forming a groove at the foot; a 3 × ¾ inch casing to be run round the openings and scribed to the doors; *Fastenings to doors.* each door to have an exterior handle and fastening inside; all boarding between storey posts, exterior passage from granary, &c., to be against split rails and ¾ inch rough fittings. *Manger.* Quarter circular cast-iron manger 2 feet radius to be fixed in all the cattle and cow-boxes, and also pig-boxes in 1·9 radius; a semi-circular water trough of the same radius to be fixed to each pair of cow and cattle boxes.

Troughs. The sheep ties to have cast-iron troughs, one to each pair of ties for water, 1 foot × 6 in. × 6 in., and one manger to each tie of the same description and size.

Fodder racks. A green fodder rack formed with top and bottom rails and vertical staves 1 foot deep, to be fixed above the mangers the whole length of the ties; cast-iron mangers (¼ circles) and wrought-iron fodder racks to be fixed in nag stable and horse-boxes, secured by flanges to storey posts; *Water trough.* a poplar water-trough to be fixed near sheep ties of the size shown, and 1 foot deep, supported upon low piers for horses to drink from. A 2 feet by 2 feet 4 × 3 frame and 1 inch ledged shutter to be fixed above manhole of wash cistern.

SLATER.—All the roofs to be covered with slates (or tiles)—slates to be laid on battens, to have a proper amount of lap, and each slate to be secured with two copper nails. Ridges to be furnished with plain or ornamental ridge tiles.

PLUMBER.—All the flashings to be of lead, weighing 5 lbs. to the foot superficial. The hips and valley to be covered with 5 lb. lead.

Cast-iron down spouts to be provided, connected with tubular drain at bottom, leading to the soft water tank.

Plasterer.—To plaster or line with glazed tiles, the dairy and cheese room. Plaster with lime hair mortar the walls of barn, granary, engine room, machine room, and stables.

Ironmonger.—To provide boilers to food-cooking houses, and to dairy, and all necessary locks, hinges, staples, and the like.

Painter.—To give to all internal and external wood three coats of paint of colour as directed.

Glazier.—To provide for windows of engine room panes of Chand's corrugated glass, and for all other windows crown glass, of weight and dimensions as directed. Descriptions of fittings will be found in Essay Tenth in this work, and working drawings of *doors* and *windows* in Plates XLIV., XLV., XLVI., and XLVII., of *roof* in Plate XXXVI.. and of *shedding* in Plate XLIII.

13. To make our examples of specifications complete, we deem it advisable to give here, one adapted for *labourers' cottages*, as approved by the Lords Commissioners of Her Majesty's Treasury, for the guidance of the Commissioners of Public Works:—

The foundations to be sunk at least 1 foot 6 inches under the surface of the ground, and the vegetable mould for 9 inches deep to be removed from the whole area of the cottage. After filling in the trenches, the surplus earth remaining is to be spread about the walls outside, so as to give a good fall out from the walls on all sides.

The walls to be built of stone or brick, as may best combine efficiency and economy; the quoins, jambs, and arches (or lintels in place of arches), chimney breasts and shafts, to be built of either stone or brick, as the locality affords cheapest and best; all stones to be laid on the flat or quarry bed, and to be full flushed and filled with mortar and spawls, and the two faces to be bonded together at every four or five feet, and the joints full pointed flat on both sides, to take lime-whitening. Where chimney shafts pass through the slating, the joints of the shafts over the slating to be carefully and deeply raked out after the slating is done, and a mortar fillet to be run round the shaft to throw off the water.

The steps to doors and window-sills, and hearth-stones to be of rough punched ashlars, when they can be procured; if not, of flags laid with a slope to throw off the wet.

The roof to be formed of foreign timber, red or white deals, the rafters to be 4½ inches by 1½ inch, and to be spaced 12 inches from centre to centre; the collar ties to be 3 inches by 1½ inch to each pair of rafters, the ridge-piece, 7 inches by 1½ inch.

The covering of roof to be of ladies' or countesses' slates, laid on sawn laths, 1½ inch by ¾ inch (24 to the deal), with at least 3-inch lap or cover, and thorough rendered with dry mortar mixed with cow-hair, or dried cow-dung well beaten and sifted.

The wall-plates and tassels to be 3 inches by 3 inches, bedded level in mortar, and halved and spiked at heading joints or crossings.

The ground floor joists for bed-rooms to be 4½ inches by 1½ inch, trimmed for hearths; the floors of ¾-inch deal, planed on one side and laid folding.

The outside door to be of 1-inch deal, planed on one side, rebated, beaded, and ledged with 3 ledges, each 9 inches by 1½ inch, hung with strong hook-and-eye hinges, with a strong stock-lock and thumb-latch, and 2 12-inch flat iron bolts. The frame to be 4½ inches by 3 inches, the joggles to run 6 inches into the wall, with 3-inch lintel spiked down on it; 3 inches by 1-inch wrought stops to be planted on the frame, and the feet to be secured to the door-sill by wrought-iron spuds and rings.

Timber lintels to be fixed over all opes, and to be 3 inches thick and 1 foot 6 inches longer than the clear ope.

The sashes to be of 1½-inch deal, with chamfered bar in small panes, or simply rebated to receive a cast-iron sash; and to be made in two heights, the lower to be fixed and the upper hung on pivot hinges, as shown on enlarged drawing. The meeting rail to be splayed and rebated; the frames to be 4½ inches by 1½ inch, with ¾-inch inner casing to fill up reveals, with 1½ inch by ¾-inch wrought and rounded fillets, inside and outside, and 1-inch, planed on one side, rounded window-board laid level, fixed on rough deal bearers.

The kitchen floor to be formed in any of the following ways:—

1st. With deal, as before described, *which is not recommended.*

2d. With hard, well-burned, and well-shaped bricks on edge. *Unless these are very good, they are very hard to keep clean, and liable to great wear and tear.*

3d. With any flags that will make a dry floor. This will only include free-stones and granites.

4th. With English or Irish tiles.

Memorandum as to laying of tile or brick floors.—In proceeding to lay tiles or bricks, the best course is to fill in to about 3½ inches of the underside of floor with lime-riddlings and spawls, and bring them to a rough level, and pour over them a grout of lime and sand. When this is dry, lay 3 inches of cement concrete in the proportion of about one of cement to five of sand and gravel, and float over the upper surface of this carefully with half-an-inch thick of fine cement mortar from properly levelled screens. When this has set, proceed at one end of the room to lay a tile at each corner; accurately level these two, and against them press a long straight-edge of same thickness as the tiles, securing it in its place; then remove these tiles and fill in between the straight-edge and the wall with enough cement to form a coat of about ⅛-inch thick, which must be mixed thin; roughly float this and lay in the tiles, skin to skin, with the trowel, and a smaller straight-edge; force them down to a level all across the course, and make all the joints equal, and spread the surplus cement forced up through the joints over the surface of the tiles and into any open joinings. Proceed to lay a second course in the same way, with this exception—that the short straight-edge will then be available for levelling the cement in the new bed; the long straight-edge is in every case to be secured in its place on each shift by driving into the concrete close behind it a couple of iron points before removing the two guide tiles. The tiles must be kept in water until laid; and after one or two courses the surplus cement must be washed off with a wet cloth and plenty of water. After two days run the whole surface over with thin cement grout, which coax into any open joints, and wipe over the surface when set with a cloth and water. If a little more care be taken to grout and solidify the first filling, the cement concrete may be saved. The *cost* of such a floor of English tiles, red and black alternately, and laid diagonally, is about, for one yard, in the city of Dublin—

	s.	d.
Tiles,	2	9
Labour and laying,	1	9
	4	6

The tiles are 6-inch tiles, and 75s. per 1,000; labour only of laying, 6d. to 7d. per yard; cement, &c., the balance.

For skirtings to timber floor, deals, 3 inches by ¾-inch, planed one side and chamfered on edge; to other floors skirtings of cement about 2 inches by ¾-inch, the wall-joints having been first well scraped and the wall thoroughly wetted to cause the cement to adhere.

For ceiling rooms use 5 or 6 leaf deal, planed on one side, which may be afterwards papered or painted, or simply oiled (cost about 2½d. to 3d. per foot), or lath and plaster in the usual way.

In a turf country, form a hearth of fire-brick on edge, and line the back of wall with same; where coal is burned, a cottage-range can be bought for £1, requiring no setting; or an open fire-place of ¾-inch wrought-iron bars at front and bottom, and strong frame, and about 2 feet 6 inches long, should be let into stone hobs at each side; if the stone is likely to be affected by fire, protect it by blocks of fire-clay tiles, and back the fire-place with fire-brick, sloping towards the front, so as to leave only 4 inches wide of fire at the bottom.

Make the internal doors and frames similar to the external, except that the doors need not exceed ¾-inch in thickness, with 1-inch ledges and lighter hinges, with a thumb-latch and one small bolt.

The privy to be built with walls as before, 5 feet by 2 feet 6 inches inside, and door and frame as for internal doors; the roof with rafters 3 inches by 1½ inch, 3-inch lintel over door serving as wall-plate; the seat and riser of 1-inch deal, on strong brackets of rough deal; the floor to be formed of flags or 1-inch deal, and 3-inch by 3-inch joists, in each case resting on the offsets of the wall enclosing the cesspool, and arranged so as to be easily removable for the purpose of emptying.

The walls inside of house and privy to be whitened with lime and size, and the wood-work painted in 3 coats of oil colours inside and 4 coats outside.

Partitions.—When partition walls are required, it is desirable that they should occupy as little space as possible. It will, therefore, be generally best to build them of 4½-inch brick; but for mere separation of the sexes a timber screen may suffice, formed of ¾-inch boards, nailed to 3-inch by 3-inch uprights, with head and sole pieces of same scantling, pasted over with paper.

Upper Floors.—The floors and skirtings to be same as for ground floors. Joists, 9 inches by 1½ inch, spaced 12 inches apart from centre to centre, on 4-inch by 3-inch wall-plates, will suffice for 14 feet bearing.

14. In concluding our remarks upon, and examples of, specifications and contracts, the following *memoranda*, in various points connected with these, will be of service to the young architect and builder. (1.) From the unhappy frequency of strikes among the artificers connected with the building trades, it is advisable to insert in the specification a special clause bearing upon this subject. The following is the clause inserted in the specification drawn up by a well known metropolitan architect:—" —— to be completed within —— months from the time of commencement, finished fit for occupation, subject to a penalty of £—— per week, to be deducted from the amount of this contract as and by way of liquidated damages, for such period exceeding that time, that the works are unfinished, which penalty will be rigidly enforced by the architects; provided, nevertheless, that no penalty for delay in the completion or due prosecution of the works shall be recoverable in case a delay shall arise, or be caused by a general strike of the workmen in the metropolitan districts, as shall not in the judgment of the architects have arisen from the misconduct of the contractor or his foreman." (2.) As regards the contract itself, we would strongly urge the client and contractor to examine each for himself the whole of its clauses. It is really one of those "stupid things" which every one denounces—but too many do—when the client or the contractor *takes for granted* that the contract between them, and which they both duly sign, embodies all that is necessary to secure their individual interest. One-half of the disputes which arise over building questions owe their existence, we venture to say, to the gross ignorance under which the parties interested *prefer* to lie as to the clauses of the contract which binds them both. We say prefer advisedly, for they have, if they please to use it, the right to investigate the contract. It was but recently we had a case to adjudicate upon, in which the client *thought* a certain clause was inserted in the contract, which turned out, after examination, to have been omitted. (3.) Let the contractor on the one hand, therefore, be fully aware of all the conditions of the contract; and further, where the work is of any magnitude let his solicitor be employed to examine it, and to obtain a duly certified and signed copy of it, to which, whenever necessary, he may refer. On the other hand, let the client see—or his architect for him—that the contract is rigidly followed in all, and even in the minutest part. For it is not generally, or perhaps not universally, known, as it ought to be, that if the client waives any part of the contract he invalidates its other conditions; so that if disputes arise he will find himself without *a remedy*. (4.) It is worthy of remembrance, that where a contractor finds out that a contract has been based upon fraudulent representations as to the amount of work really to be done, he cannot sue for the value of the work done unless he repudiates the contract as soon as the fraudulent representations are proved or show themselves. (5.) As named in another part of this Essay, there is nothing connected with the relation subsisting between clients and contractors so fruitful of disputes as *extra work*. Where a contract specifies—as it ought to specify—that no extra work will be paid for unless distinctly ordered by the architect in writing, the contractor should be particular in having the written order, for unless he can produce it, the employer may, if he pleases, refuse payment for the work. In order to remove all doubt as to the terms of the order, care should be taken to see that every point is stated in the most explicit way. A drawing of the extra work to be executed, duly signed by the architect, is held in law to be "an order in writing." (6.) In order to serve as a basis for the charges to be made for extra work, a schedule of prices is provided, sometimes by the contractor, and deposited, sealed, with the architect. This is legally the property of the contractor only, and should be delivered to him by the architect on the conclusion of the works. (7.) Where a certain amount of work is contracted to be done for a certain sum, and extra works are done, or the contract is set aside, the employer is frequently asked to pay a further amount over and above that specified; this gives rise often to disputes, and it is well to know the legal finding as to "deviations from contracts." "Where additions are made to a building which the workman contracts to finish for a certain sum, the contract shall exist as far as it can be traced to have been followed, and the excess only paid for according to the usual rate of charging; but if a man contracts to work by a certain plan, and that plan is so entirely abandoned that it is impossible to trace the contract, and say to what part of it the work shall be applied, in such case the workman shall be *permitted to charge for the whole of the work by measure and value, as if no contract had been made*. Where deviations from the contract can be proved to have caused extra expense, and that the employer was aware that such extra expense would be brought about by the deviation, Gibbons, in his 'Law of Contracts,' holds that 'the builder is only entitled to recover the value of the extra labour and materials so rendered necessary.'" (8.) It is further worthy of notice, that where extra works have been done, the contractor can claim payment for such, even although it can be shown that he has not fulfilled the terms of the contract, or even before the time for paying the contract sum has arrived. (9.) All these points above alluded to still further show the importance of knowing fully the nature of the work to be done in any erection, and the terms of the contract connected with it being fully considered at the beginning; and the necessity—if disputes are to be avoided—of allowing no extra works to be done or the terms of the contract departed from without the full knowledge of, and the written consent obtained from, the client or his architect.

15. Much discussion has been given of late to the question as to what are the *legitimate charges* which architects should make for preparing plans and specifications and superintending the erection of the structures to which they refer. It is not our intention here to enter into the details of this discussion, but simply to give here the "scale of professional charges agreed upon by the Architectural Alliance,"—a scale based upon other scales published, embodying, therefore, as may be reasonably inferred, all the points which the profession deem of importance to be enforced.

"(1.) The usual remuneration for an architect's services, except as hereinafter mentioned, is a commission of 5 per cent. on the total cost of the works executed from his designs; besides which, all travelling and other incidental expenses incurred by the architect are paid by the employer, who is also chargeable under certain conditions, as hereafter mentioned, for time occupied in travelling. But for all works in which the art required is of a high kind, and the expenditure mainly for skilled labour and not for materials, *e. g.*, in designs for the furniture and fittings of buildings, for their decoration with painting or mosaic, for their sculpture, for stained glass, and other like works, the architect's charge is not made by way of commission on the cost, nor does it depend upon the time employed in making the design, but is regulated by special circumstances, and varies according to the skill and artistic power of the architect. In certain cases, where very simple construction, much repetition, and great proportionate outlay are involved, a lower rate of commission may be charged. This lower rate should be a matter of special agreement.

(2.) In works under £500 in amount, 5 per cent. is not fairly to be considered remunerative, and in such cases it is just to the employer, as well as to the architect, to charge by time or by a scale, varying from 10 per cent. for works under £100, to 5 per cent. on amounts above £500.

(3.) The commission is reckoned upon the total cost of the works, valued as if executed entirely by labour and of new materials provided by the builder.

(4.) The commission is to be charged upon the whole value of the work executed, with the addition of 2½ per cent. upon any omissions. This is exclusive of the charge for measuring extras and omissions.

(5.) The architect is entitled during the progress of the building to payment on account, at the rate of his commission, on the instalments paid to the builder, or otherwise, to half the commission, on the signing of the contract, and the remainder on the instalments.

(6.) All travelling expenses are to be charged extra.

(7.) These rules suppose the work to be executed within an easy distance of the architect's office; but if the work be executed at a considerable or inconvenient distance from it, an allowance beyond the commission ought to be made for the *time* occupied in travelling, in addition to the actual expenses.

(8.) The per-centage does not cover professional services in connection with negotiations for site, arrangements respecting party walls, or right of lights, nor services incidental to arrangements consequent upon the failure of builders whilst carrying out work; but all such services are charged for in addition, the basis for charge being the time employed.

(9.) Supposing that the employer, after having agreed to a design, and had the drawings prepared, should have material alterations made, an extra charge may be made according to the time occupied.

(10.) If the architect should have drawn out the design complete, with plans, elevations, sections, and specification, ready for estimate, the charge is half the usual commission above named.

(11.) If the architect should have, in addition, procured tenders in accordance with the instruction of his employer, the charge is one-half per cent. extra to the above.

(12.) As the architect is employed to prepare complete drawings and specification for a building which it is not intended that he shall personally superintend, he is entitled to charge three-quarters of the full commission. But in cases coming under the description in Clause 3, the charge for plans, specification, and working drawings only should be a matter of special arrangement.

(13.) For works in the alteration of premises, the remuneration may be increased according to the time, skill, and trouble involved.

(14.) All of the following requirements for buildings are included in the ordinary charge of 5 per cent.:—Preliminary sketches; working drawings and specifications sufficient for an estimate and contract; detailed drawings and instructions for execution; general superintendence of works (exclusive of clerk of the works); examining and passing the accounts (exclusive of measuring and making out extras and omissions).

(15.) No additional remuneration is due for making such a rough estimate as may be obtained, for instance, by cubing out the contents. If a detailed estimate be framed, additional remuneration is due from the employer.

(16.) An architect is bound, under the 5 per cent. charge, to provide one set of drawings and one set of tracings, with duplicate specification; it being understood that the architect is paid for the use only of the drawings, tracings, and specifications, and that they remain the property of the architect.

(17.) The charge for taking a plan of an estate, laying it out, and arranging for building upon it, should be regulated by the time, skill, and trouble involved. For actually letting the several plots (in ordinary cases) a sum not exceeding a whole year's ground-rent may be charged. For inspecting the buildings during their progress (so far as may be necessary to ensure the conditions being fulfilled) and finally certifying for lease, the charge should be a per-centage not exceeding one-half per cent. on amounts up to £5,000, and above that by special arrangement. All the above fees to be exclusive of travelling expenses, and time occupied in travelling, as before mentioned.

(18.) The charge for the above does not include the commission for preparing specification, directing, superintending, and certifying the proper formation of roads, fences, and other works executed at the cost of the employer, nor for putting the plans on the leases.

(19.) The charge per day of seven hours which may be made by architects depends upon their professional position, but the minimum charge is three guineas per day. The charge for assistants to be one guinea, and junior clerks half-a-guinea.

(20.) The charge for surveying and estimating dilapidations is 5 per cent. on the estimate, and in no case less than £2 2s.; but when no estimate is made the charge to be by time.

(21.) When quantities are required for tenders, it is desirable, unless the client have appointed the architect himself to prepare them, they should be taken out by an independent professional man. It is now customary for the contractors to pay for the quantities; but it is desirable, and especially when they are taken out by the architect, for the client to pay for them directly, and that they should form part of the contract."

16. *Estimates.*—Before estimates can be given *quantities* must be made out. Quantities are usually made out by surveyors; those who take a high view of the position of an Architect, deeming that it is beneath the dignity of his profession to act as a Surveyor, and provide quantities for any building of which he prepares the plans and specifications. Opinion, however, is divided throughout the country on this point amongst architects; in London it may be said to be the rule that the union of the duties of an architect and a surveyor are considered as incompatible—at all events, that it is more professionally consistent for the architect not to take out and furnish the builders with the quantities. Thus, the "Institute of British Architects" makes a marked distinction between architects and surveyors, granting the latter the position of "Associates" only, but debarring them from the higher and more honoured grade of "Fellows." In the provinces such exclusive views—we do not here, for obvious reasons, enter into any discussion of the question whether these are right or wrong, politic or impolitic—are not held as a rule, many architects combining with their higher duties those of the surveyor. It is, of course, understood that in all cases the expense of taking out and providing a bill of quantities is independent of, and additional to, the architect's charges for preparing the plans and specifications; it follows, therefore, where the architect does take out and provide a bill of quantities, he is entitled to a separate payment for the same. One important point bearing upon this question is this—and it is too often overlooked by architects—that if an architect does take out himself and provide a bill of quantities—assuming thus the office of a surveyor—he assumes also its responsibilities, so that he may become personally liable for losses sustained in consequence of errors which he may have allowed to creep into his quantities. It is necessary, however—as appears from the case of Kemp *v.* Rose, as stated by Mr. Glen—that to make the architect thus liable the client shall pay him the proper surveyor's charges for the quantities. The charge for making out a bill of quantities is usually from 1½ to 2½ per cent. on the cost of the buildings, the larger amount being that charged for extensive, the smaller for limited erections. Where a surveyor is employed to measure up and value "ex-

tra work," he is usually paid a sum valued at 2½ per cent. on the cost of such extra work. Surveyors who are independently employed, are, as a rule, supplied with a copy of the drawings referring to the building to be erected. In some cases, however, architects make a charge for these. In any case, by whomsoever made out—by the architect himself or by a specially engaged surveyor—we would strongly urge upon the contractor the benefits to be derived from the plan of thoroughly examining and testing the quantities so provided before the contract is signed. It is obvious enough that it is of essential importance for him to know whether the quantities are correct upon which he bases his estimate. If errors are discovered either reducing or adding to the amount of the estimate, it is in every way the best mode for all parties concerned to have these adjusted before the work is commenced. It can be in no sense a pleasant thing for the architect to be mixed up with disputes between builders and clients at a later stage of the proceedings when errors are discovered, but when it is too late easily and without dispute to rectify them.

17. The quantities being duly provided, it seems unnecessary to point out the importance to the contractor of his taking every care that his estimates founded upon them shall be correctly made; and yet it is not making any new statement when we say that many estimates are mere "guess work." In estimating, as in all work, there are two ways—the right and the wrong one—to be followed, it will be well to glance briefly at the leading points to be attended to if the right way is aimed at. After estimating from the quantities provided—that is, rigidly following out every detail, not contenting oneself with *calculating* a portion of the work and deducing the value of the remainder from an *estimate* (or guess)—it will be well to *test* the accuracy of the calculation of value of work to be done as *founded upon the quantities;* by cubing the contents of the building and pricing these contents at so much per foot, from 7d. up to 1s. 2d., care being taken to measure up every part. In place of "cubing," another plan adopted to make a rough estimate of the cost of a building is to calculate the area of the ground it occupies, and estimate it at so much per square; but the plan of cubing is by far the best and most trustworthy. A method which the writer calls "detailed approximation" is thus described in a professional journal; it is the plan followed usually in competition for extensive works on the Continent, where the competitors are required to send in bills of quantities, priced according to specified rates made known in the terms of competition. These quantities are arranged in the usual way; but the opportunity is afforded also of giving, wherever possible, "a number of different things, which could, however, be all measured together at one time, in one item, and at one comprehensive price, and also of taking at a price to cover one complete, those articles that are frequently repeated. "For instance, it is a common thing to find a price for floors to include at per square metre, or other superficial measure, along with floor-boards, joists, and plates, the lathing, plastering, and finishing to ceiling below; or again, a price for plastering walls, to include all rendering and preparing, and painting or other finishing, and also skirting at bottom of a given height, and cornice at top. Another price will be given for floors on arches, to include floor-boards, slight-joists, concrete filling-in, arches, centres to same, and plastering soffits; while another price will include roof, at per square metre measured horizontally, of such a steepness of pitch, with trusses, purlins, rafters, and covering (of slates or tiles as the case may be), and gutters; while again other prices will be given for a door of certain dimensions, and door-frame fixed complete, with hinges and door furniture, and painted; and another for a window glazed, and hung and painted, including fastenings, fittings, shutters, and every other thing necessary to entire completeness. It can easily be seen that by the use of this method, which can, of course, by due care in the preparation of the prices be made reliable, a tolerably close estimate can be formed in one-tenth the time necessary for a complete analysis of all the work. It is a plan that does not seem to be very popular in this country, and yet it has much to recommend it to the architect and even to the contractor, to whom sometimes the means of rapidly making such an estimate as he knows he can bear out in practice is of great value, as enabling him to secure work that might otherwise go to some other quarter or to competition."

18. It will be interesting to give here the scale of charges as published by a few Architects. For these we are indebted to the pages of the "Building News." The first is that given by Mr. F. Goodman, in his work, "Domestic Architecture:"—

"For General Plans, Elevations, Working Drawings, and Specifications containing full Particulars and Form of Contract.

For one or more houses not exceeding	£200	£16
For one or more ,, ,,	500	25
For one or more ,, ,,	750	30
For an ornamental cottage or villa not exceeding	1,000	40
For ,, ,,	1,500	45
For ,, ,,	2,000	50
For all exceeding £2,000 at 3 per cent.		

If engaged as architect to superintend any building amounting to £2,000 and upwards, provided the drawings of every kind, specifications, and forms of contract are to be finished, the charge will be 5 per cent. on the amount at the building. The expense of the journeys to superintend, to be paid by the employer, and also the clerk of the works."

19. The following is that given by Mr. Ricauti, in his work on Rustic Architecture.

"Mr. Ricauti having observed in many instances that gentlemen are deterred from employing a 'professed architect, because they do not know into what expenses it might lead them,' he here inserts his terms for making designs of buildings, and for superintending the erection. If, however, the estimate of a building should exceed £1,000 no charge is made for the drawings, but the architect receives a commission of 5 per cent. on the cost; and his travelling expenses in all such cases are charged to the employer.

In preparing a set of drawings, the style of architecture in which they are designed will not in the least degree heighten the following charges, which are founded upon the relative proportions, and quantity of work required, in making out the drawings, &c., for various designs:—For making plans, elevations, sections, and perspective sketch of a small building, such as a gate-lodge, green-house, labourer's cottage, &c., the estimate not exceeding £100, £3 3s.; for making the working plans of ditto, £2 2s.; for a building, the estimate not exceeding £150, £4 4s.; for making the working drawings of ditto, £3 3s.; and so on in proportion, adding one guinea to the expenses of the drawings for every £50 added to the estimate. For a visit of superintendence, or to examine and report upon the site for a building, requiring but one day's time, including travelling and all expenses, £4 4s.; for a visit to any place requiring two days' time, and travelling expenses, £8 8s.; and so on in proportion, adding four guineas for every additional day, which includes the charges for travelling and all expenses."

EXPLANATION OF THE PRINCIPAL TERMS

USED IN

ARCHITECTURAL DESIGN AND BUILDING CONSTRUCTION.

SECTION FIRST.—TERMS USED IN ARCHITECTURAL DESIGN, CLASSICAL AND GOTHIC.

Abacus (in *Classic Arch.*).—The Abacus, literally a *table* or *slab*, applied to the uppermost division or member of a capital. *In the Grecian Doric*, fig. 1, Plate D, the Abacus has simply the form of a square tile without either chamfer or moulding. *In the Roman Doric*, fig. 2, Plate D, it has the addition of an ogee and fillet round the upper edge. *In the Tuscan*, fig. 3, Plate D, it has a plain fillet, with a simple cavetto under it. In the above orders it is of considerable thickness, and the moulding round its edge is called the *cimatium* of the abacus. *In the Grecian Ionic*, fig. 4, Plate D, it is worked much thinner, consisting of an ovalo, generally without any fillet above it, and is sometimes sculptured. *In the Roman Ionic* it is the same as the Grecian, with a fillet above it. In all the above orders in ancient architecture, and also in all except *a few instances in the Ionic in modern*, the abacus is square in plan. But in the Corinthian and Composite Capitals, figs. 5 and 6, Plate D, and the few modern Ionics, the sides are hollowed and the angles truncated. The abacus of the Corinthian and Composite consists of an ovalo on the upper edge, and a fillet and cavetto beneath. The mouldings of the modern Ionic vary when not square in form. An ogee and fillet, like the Roman, are the most common.

Antae (in *Classic Arch.*) are square pillars terminating the flank walls of a Greek temple which receive or support the architrave. They project slightly in breadth on each side of the wall. The faces of the antae opposite to columns are the mean width betwixt the superior and inferior diameter of the column, but the face on the flanks is always much narrower. They have capitals totally dissimilar to those of the column. Fig. 7, Plate D, shows the wall terminated by antae, which are covered in front by columns. Fig. 8, Plate D, the capital of antae in the Doric temple of the Parthenon. Fig. 9, Plate D, the Ionic temple on the Illyssus. A *portico in antis* is when columns stand between antae. A *temple in antis*, when the whole front or *pronaos* is formed of the projection of the *pteromata*, or side walls terminated by antae, with columns between them. Antae are the supposed original of the modern *pilaster*.

Antefixæ (in *Classic Arch.*), upright blocks, ornamented in the face, placed at intervals on the highest member of a cornice. Fig. 28, Plate D, are antefixæ in the Parthenon at Athens.

Apse (in *Gothic Arch.*), a semicircular recess, usually vaulted with a semidome, where, or in front of which, in early churches, the principal altar was placed. In the Norman the ancient semicircular form obtained, but in the pointed styles it was changed to polygonal. It was sometimes called Concha, and also Exedra. It is generally placed at the east end of the choir or chancel, with sometimes a double apse at the west end, but also at the sides of the choir and projecting from the transepts. Fig. 29, Plate D, is perhaps the best specimen existing of a pure and rich Norman apse.

Base (in *Classic Arch.*) is the lowest part of the column supporting the scapus or shaft. It gives the column, besides a broader foundation, a sort of girding at the lower end of the shaft. It is suitable for slender and more developed forms of column. *In the Grecian Doric* of all the three kinds, the shaft being of great solidity, ascends without base or plinth immediately from the pavement, which is raised upon three steps. The steps are not proportioned like those in a common stair, but have relation to the magnitude of the edifice. *In the Roman Doric*, according as the shaft is more or less slender, there is either only a simple fillet, or fig. 10, Plate D, a base, consisting of (1) a torus, a plain astragal (2), a fillet (3), 16⅓ min. of a module in height. The Plinth (4) is only found in the latter, and is a *square* slab placed under these mouldings, 13⅓ minutes of a module in height. *In the Tuscan*, fig. 11, Plate D, which is a variety of the Doric, the base consists of (1) a torus; and (2) fillet. The Plinth (3) is *circular*. The plinth and base are each 15 minutes in height. The *Attic Base*, fig. 12, Plate D, is the name given by Vitruvius to a variety used in all the Athenian Ionic, and in many Corinthian and modern buildings. It consists (1) (2) of an upper and lower torus, having (3) a scotia or trachilus between them, separated by fillets (4) (4). In some richer Athenian Ionic, as in the temple on the Illyssus, there is added to the attic a bend and fillet (5) on the upper torus, the fillet joining to the scape of the column. In most of the bases used in the Athenian Ionics there is no plinth, the attic base resting directly on the pavement. In others, however, and in the Roman Ionic, the attic base has generally its plinth, a square slab (7) of greater height (23½ minutes) than the base (19⅔ minutes). The *Ionic base proper*, chiefly prevailing throughout Ionia, consists of (1) plinth, (2) scotia, (3) upper scotia, (4) torus, and the separating and preparatory fillets. *In the Greek and earlier Roman examples of the Corinthian order* the attic base was chiefly employed. In *Choragic monuments*, however, fig. 13, Plate D, the structure supported being light, the shafts are slender, and the base rises from a circular platform. It consists (1) of an elegant bell-shaped moulding separated from the platform by (2) an astragal and fillet; (3) a torus with a fillet above and below; (4) a scotia; and (5) an upper receding astragal, with a fillet on each side. *Corinthian base.* In the later examples of the Corinthian in the Roman empire, this nation sought to give it a distinctive character by bestowing on it a peculiar entablature and base. The Corinthian base rises, fig. 14, Plate D, from (1) a small square plinth, and comprises (2) (2) an inferior and superior torus separated by an inferior and superior scotia (3) (3), each with a fillet above and below it, having two astragals and a bead between them (4) (4). The whole is surmounted with a large fillet, whence the scape ascends.

Boss (in *Gothic Arch.*), figs. 15, 16, and 17, Plate D, is a projecting ornament placed at the intersections of the ribs of ceilings; also used as a termination to weather mouldings of doors, windows, &c., but principally to vaulted ceilings. In Norman work bosses were used only in the late period of that style, and were not prominent nor richly carved, fig. 15, Plate D. In the early English they are used in profusion, and are elaborately carved, generally with foliage only, or foliage with figures and animals introduced, fig. 16, Plate D. In the Decorated, fig. 17, Plate D, and Perpendicular styles, the bosses are similar, but less delicately worked in the latter; they consist of either foliage only, or of heads or animals only, or of all combined, and frequently of shields with armorial bearings. The bosses of vaults were anciently called *keys* and *knots*. In the perpendicular style they present great variety, and sometimes resemble pendants.

Buttress (in *Gothic Arch.*), supposed to have originated in the pilaster of the Byzantine style, which, again, is derived from the antæ of the classical orders, but may sometimes have been suggested by the semi-engaged column in side walls of pseudo dipteral temples; examples of the round buttress occur in earliest Norman in that style, figs. 18 and 19, Plate D; they are of considerable breadth and very small projection, adding little to the strength of the wall, not commonly divided into stages, but of same breadth and thickness throughout, either dying into the wall with a slope below the parapet, (fig. 18, Plate D,) or continued up to the parapet, which, in that case, overhangs the wall as far as the projection of the buttress in order to receive it. *The Arch Buttress* is an arch-formed prop which connects the walls of the upper and central portions of an aisled structure with the vertical buttresses of the walls. Where employed in Norman buildings they are concealed within the roof of the side aisles, but an idea of them may be formed from fig. 20, Plate D, where the external buttress (which is, however, in the early English or succeeding style) is detached from the wall in its lower portion in order to obtain the projection necessary to carry the arch upward from its base. The buttresses of the early English style have considerably less breadth and much greater projection than the Norman, and often stand out very boldly; sometimes continued without diminution, but oftener broken into stages, with a successive reduction in their projection, and even in their width. They terminate generally with a triangular pediment, sometimes, as in fig. 21, Plate D, below the parapet, sometimes, fig. 20, Plate D, standing against it, and but rarely, and only in late works, sometimes rising above it in the manner of a pinnacle. At the angles of buildings they usually consist of a pair, one on each side of the angle, (fig. 21, Plate D,) but sometimes of one large square buttress entirely covering the angle. *Arch Buttress.*—In the early English the arch buttress stands clearly above the roof, and is sometimes employed, as in fig. 22, Plate D, when no aisle is attached to the buildings, when, as also in fig. 20, Plate D, the vertical buttress stands out with a great projection from the wall.

Capital (in *Classic Arch.*).—The capital of an order consists of—(1) the *Abacus;* and (2) the *Bell, Basket,* or *Vase,* of the Capital, in the Corinthian and Composite orders, and in other capitals, Gothic, &c., which partake of this form, is the body of the capital beneath the abacus, fig. 23, Plate D, *supposing the foliage dropped off.* The Bell is covered with *Acanthus* or leaves A A A A in two rows. In this example the lower row is plain, and the upper is ruffled; in most others they are both ruffled. In the Attic Corinthian these leaves were pointed in imitation of the Acanthus (whence the name). In Italy, they most generally resembled the olive. In this figure the lower row consists of sixteen leaves and the upper of eight; in most others there are eight in each row of equal height. *Helices; Cauliculi;* or *Stalks* (B B); which occupy the space between the upper leaves and the abacus, and spring between every two leaves in the upper row, as if proceeding from one common vertical stalk; they first throw out foliage, and then terminate in *Volutes,* or spiral scrolls (c c c c) which proceed to the lower side of the corners of the abacus and also to the middle. The volutes in the middle of the capital are quadruple in this example, one each of each pair of one side, meeting each one of the other pair on that side. These four volutes form a curved four-sided figure. In most other examples the volutes in the middle are only double, consisting of the upper two of this specimen, but enlarged in form. The Ionic order has also volutes at each corner of the abacus. *The Pin* or *Rose* E E by which the leaves appear as if fastened to the body or bell. This is not found in *other examples. Honeysuckle* (D D), supported by the upper or lesser pair of volutes of the middle of the bell.

Clear-Story (in *Gothic Arch.*), sometimes Clere-Story, is any window, or row of windows, or openings in the upper part of a building, wall, or screen. In the modern medieval language the clere-story refers to the upper part of the central aisle of a church in which windows are formed above the roofs of the side aisles, as in fig. 27, Plate D, where this term properly applies to the uppermost windows in the central wall, and not to the upper ones in the wall of the side aisle. When the latter (the upper windows in the side walls) are connected with a triforium, or upper gallery, extending backward to them, they are called triforium windows. The clere-story appears to have been adopted in churches as a means of increasing the light in the body of the building. In many Norman and later styles it is an original feature, but instances occur of its being adopted as an addition when the high-pitched roofs (including body and aisles in one span) have given way to flat ones, and walls have been built over the arches of the naves to receive the clere-story windows.

Corbels (in *Gothic Arch.*).—Corbel, a name peculiar to medieval architecture,—is a projecting stone or piece of timber which supports a superincumbent weight. Corbels are used in a great variety of situations, and are carved in various ways according to the taste of the age in which they are executed. The form of a head was very frequently given to them in each of the styles, from Norman to Later Perpendicular, especially when used under the ends of the weather mouldings of doors and windows. Any construction which is carried by corbels, so as to stand beyond the face of the wall, is said to be *corbelled out.* A corbel corresponds to a console or a bracket, but the former is the term for such projections in medieval architecture. Fig. 24, Plate D, is a Norman corbel from Kirkstall Abbey, 1150.

Cornice (in *Classic Arch.*).—The different kinds of cornices are as follows:—*Mutule Cornice,* peculiar to the Doric order, has its bed moulding narrow, and projecting at intervals downward and forward in a mutule *b—b,* fig. 25, Plate D. *Architrave Cornice,* is that which rests upon the architrave (the frieze being omitted). Cornices of this description are adapted to situations where a regular entablature would be out of proportion to the body which it crowns. *Modillion Cornice,* is used in the Ionic and Corinthian orders, and has its bed moulding projecting at regular intervals into modillions, *a—a,* fig. 25, supporting the corona, instead of mutules, as seen in the Pantheon at Rome. *Dentil Cornice,* (in the Ionic and Corinthian orders,) is distinguished by a denticulated band or ranges of dentils, *b—b,* fig. 26, Plate D, in the bed moulding, which is heightened by mouldings placed above and below, as seen in the monument of Lysicrates. *Dentils b* are similar and equal projecting solids, disposed in a row of equal intervals in a cornice, and presenting four sides of a rectangular prism. *Dentil-Modillion Cornice* is when both the dentils and modillions are adopted in the projecting frieze and cornice, as in the Pantheon of Agrippa at Rome. Fig. 26, Plate D.

Echinus, or Egg and Anchor. An ornament introduced into the ovalo moulding—sometimes called therefrom an echinus—(Plate D, fig. 30*a*) consisting of a figure of an egg and dart, tongue, or anchor fluke, used in the cornices of the Roman orders, as in the Pantheon at Rome; also in the Ionic capitals, but in a bold or larger form.

Entablature (in *Classic Arch.*).—The whole of that part of the order which is supported by the column. It consists of three principal parts. Fig. 30, Plate D, illustrates an entablature; it is of the Doric order from the Parthenon at Athens—1. *Architrave* or *Beam* (B); that part which rests upon the column (A), and which represents the lintelling beam placed over the columns. In this order it is composed of one vertical face with a band or fillet (*f—f*) at its upper edge. To the under side of this band are suspended, under each triglyph and equal to its breadth, a small fillet (*g—g*) and conical *drops* or *guttæ* in a row, six in number, which are of a cylindrical form. 2. *Frieze* (C). The middle principal member which separates the cornice from the architrave. Friezes are of various forms, usually flat, but sometimes convex, and in a few instances formed of two curves of a contrary flexure. In this order the frieze consists of (1.) *Triglyphs* (*t t*), which are rectangular projections in tablets placed alternately with the Metopes. Their height is rather more than their breadth. They are cut vertically into two angular channels—whence their name—with half ones on the extreme edges. Each channel is formed by two planes meeting at its bottom at a right angle, and each forming an angle of 135 degrees, with the face of the tablet. The upper ends are terminated in various forms. (2.) *Metopes* (M), which are square recesses in the frieze between the triglyphs, and are frequently decorated with sculpture. (3.) *Cornice* (D). The Cornice of an order is a secondary member of the order itself, or a primary member and the upper part of the entablature. Cornices are generally divided into three parts—(1.) The bed moulding, *a a.* (2.) The corona, *b.* (3.) The cymatium or upper moulding, *c c.* The *Corona* is the principal member of the cornice. It has a broad vertical face and a bold projection. It is often called the *drip,* from its discharging rain water in drops from its edge. It is also sometimes called the *larmier.* Cornices are of several kinds—1. A *Mutule Cornice,* peculiar to the Doric order. The *Mutule* is represented at *a—a,* and at *a a* in fig. 30*d,* Plate D.

The Fascia or Band, with subordinate mouldings, is introduced into all the orders. It is vertical, having only a very small projection. It is sometimes repeated and triplicated with intervening mouldings, and is frequently ornamented, except in the Doric. Fig. 30*b,* Plate D, is a fascia in the Temple of Jupiter stator (Roman Corinthian)—with an Echinus moulding above and an astragal below it—ornamented with a rich scroll.

Finial (in *Gothic Arch.*) is the bunch of foliage which terminates pinnacles, canopies, or pediments.

Flutes or Flutings of a Shaft or Column (*Classic Arch.*), are prismatic cavities depressed in vertical stripes at regular distances within its surface by means of which it gains in apparent height, and also in beauty by the more lively play of light and shade. They occur in all the orders except the Tuscan. Fig. 31, Plate D, illustrates the Ionic Corinthian Flutes.

Fret is an ornament used on the faces of the corona of cornices, consisting of lists or fillets interlaced. It is also used in soffits of ceilings. See fig. 30*c*, Plate D.

The Frieze is a flat member of the entablature. In the Doric order it is always divided into the Triglyphs and Metopes, see fig. 30, Plate D. In the other orders it is found both plain and ornamented; but in the latter case only with flowers or sculpture.

Modillion; (in the Corinthian composite, and occasionally the Ionic order), a mutule of a cornice carried out into a block carved into the form of an enriched bracket or console, and giving support to the larmier or drip. Fig. 30*f*, Plate D, is the side of a modillion.

Mutule; a projecting block, which appears to support the corona and superior members of the cornice, and representing the rafter in the original modern structures. The mutule has its plane with an inclination from the roof towards the horizon, and has guttæ or drops *a a a*, fig. 30*d*, Plate D, depending from it. The under side of the mutule is called its soffit, fig. 30*g*, Plate D.

Panelling (in *Gothic Arch.*).—The abundant use of panelling on the outsides and insides of walls, sometimes entirely covering them, is a feature of the perpendicular style. It extends to Buttresses and Towers, as seen in fig. 36, Plate D, which is a curious example of a turret supported by an arch or flying buttress. Panelling, however, means any sunken compartment in wood or stone, and in wainscoting, ceilings, &c., as well as in walls.

Pediment (in *Classic Arch.*).—(It. *Frontispizzo;* F. *Fronton;* L. *Fastigium;*) the triangular cornice termination used in classic architecture, at the ends of buildings, and representing the end of a roof, fig. 32, Plate D, whose purpose was to discharge the rain over the flanks. Pediments among the Romans were exclusively applied to sacred edifices, till Cæsar obtained leave from the senate to cover his house with a pointed roof after their manner. The *Tympanum of the Pediment* is the space included between the triangular cornice, A, fig. 32, Plate D, and in edifices of a public nature is frequently ornamented with sculpture.

Pillar is the English word for the pier on which decorative arches rest in Medieval architecture. Pillars are either *simple* or *compound.* A simple pillar consists of a single shaft with its base and capital. In the Norman style simple pillars mostly prevail, and are massive, and frequently circular, with capitals of the same form or square. They are sometimes ornamented with channels in various forms, spiral, zigzag; but the simple pillar of an octagonal or square form is also frequently found in buildings of a plain character. In early English, simple pillars with circular or octagonal shafts occur frequently; especially where in the progress of an edifice the style changes as the work (which occupied sometimes many years) advances towards completion. *Clustered or Compound Pillars* consist of a central mass or BODY round which are arranged several smaller shafts. In the Norman style the simplest form is a square with rectangular recesses at the corners, having sometimes a circular shaft in each of the recesses, and a large semicircular one on two (or on each) of the faces, changing in the *transition* style to a central circular shaft, with four smaller ones or six round it. In the early English it is similar in character to the transition, but the central shaft is smaller, and the smaller shafts are often made of a finer material and polished, but sometimes worked in courses with the central shaft and filleted. In the decorated and perpendicular styles the clustered pillars have a lozenge-shaped arrangement, fig. 33, Plate D, and sometimes are a square diagonally placed, fig. 34, Plate D, becoming thus again a kind of single pillar, but having the effect of a compound one.

Pinnacles (in *Gothic Arch.*) occur most frequently in the perpendicular and the decorated styles, and are, with rare exceptions, *only in them, used in Buttresses.* A pinnacle or small spire is any structure that caps or rises above the top or roof of a building or buttress.

Porch (in *Gothic Arch.*).—An adjunctive erection placed over the doorway of a larger building. Church porches have every variety of character, sometimes plain, more frequently decorated at the arches and inside, as in the Norman and early English, fig. 35, Plate D. Sometimes also over the outside, as in those of later date. They are frequently of wood in the early English and decorated, and examples occur of having small rooms over them in all the styles.

Portico (in *Classic Arch.*).—In its present acceptation, is a range of columns forming a porch in the front of a building, and finished above with a pediment, *is the distinguishing feature of all the classic orders,* and that most availed of in modern buildings. When of four columns it is called *tetrastyle;* when of six, *hexastyle;* of eight, *octastyle;* of ten, *decastyle.* When placed in front of a temple it is called the *pronaos,* when at the back the *posticus.* A Portico *in Antis,* fig. 32, Plate D, is when the columns stand between antæ.

The Scroll is an ornament frequently introduced into the fascia. In Greece it was often painted. Fig. 32*a*, Plate D, is the painted scroll of the upper fascia in the pronaos of the Temple on the Illyssus.

Soffits.—Soffits are the under surfaces of any parts (as arches, roofs, or projections) in a building that are exposed to view, fig. 30*g*, Plate D.

SECTION SECOND.—TERMS USED IN EXCAVATION WORK.

Angle of Repose (*in Excavating*).—The angle at which heaped up material will rest without slipping down is so called; it varies with different materials as follows:—Wet clay, 16° (with horizontal line); drained clay, 45°; shingle, 39°; loose vegetable mould, 28°; sand, 22°; gravel, 40°; compact mould, 50°.

Foundations.—Figs. 37 and 38, Plate D, illustrate the mode of making foundations with the trench filled with sand.

PRACTICAL NOTES AND MEMORANDA UNDER SECTION SECOND.—EXCAVATION WORK.

(1.) A cubic yard, or single load of earth, is 27 cubic feet.

(2.) An excavation of 1 cubic foot will contain 6⅛ gallons of water. A well of 3 feet diameter in the clear will contain 44 gallons (imperial) for each foot in depth; one 4 feet in the clear will contain 78 gallons; one 5 feet, 122 gallons; one 6 feet, 176 gallons; one 7 feet, 239 gallons; one 8 feet, 313 gallons; one 9 feet, 396 gallons; one 10 feet, 489 gallons.

(3.) Calculating the distance to which earth is to be conveyed from a trench at 150 feet, or 50 yards; in compact soil, 2 fillers and 2 wheelers will be required for each digger; in loose soil the number of each required will be equal; in clay, for every two diggers the proportion of fillers and wheelers will be two and a half; in rock one filler and one wheeler will serve for three diggers.

(4.) 30 cwt. is the weight of a cubic yard of sand or gravel; 25 cwt. of mud; 31 cwt. of clay; 39 cwt. of sandstone; 26 cwt. of marl.

Artesian Wells and Rain-water Tanks.—"M. Grimaud de Caux, a French scientific man, has given considerable attention of late to the question of wells, especially for the supply of farms, and in the course of his inquiries he has produced an official report on the Artesian wells of Venice, which gives a very unsatisfactory result. According to this document, an attempt was made to supply the city with water by the means in question, and the borings were pushed to the depth of about 450 feet; the soil was peaty, and the water impregnated with organic matter charged with carbon, carburetted hydrogen and nitrogen. Seventeen wells were sunk, nine of which have already ceased to flow, and the water from the others is daily diminishing in quantity, which only give 400 litres a-day, instead of 1,250 litres which they at first yielded. It appears that the authorities are now engaged in seeking some more efficacious means of supplying the city with water. M. Grimaud de Caux has a theory that the rain supplies ample provision for the wants, not only of the inhabitants of towns, but also of country districts. He says that the well is the only source of general supply in agricultural localities, but that the water derived therefrom is very seldom wholesome, and he recommends the formation of reservoirs to receive the rain water and replace the old wells. He puts a simple case as follows:—Suppose a farmer has but an acre or two of land, his house will contain an area of roof equal to something like 90 square yards, and as the average of the downfall of rain is 76 cubic centimeters, the surface above named would produce 60 cubic metres of water per year. As regards consumption, he says:—'An adult requires 10 litres, or, let us call it, about 2 gallons of water per diem, or 3 cubic metres a-year; a horse five times that quantity, or 50 litres; horned cattle, 30 litres a head; sheep, 2 litres; and pigs, 3 litres.' He supposes the farm-house to be occupied by a man and his wife and two children, and the live stock to consist of one horse, one pig, and one cow; according to the previous statement the wants of the little establishment would only amount to 44½ cubic metres per annum, and a reservoir 16 metres square and 4 metres deep would, he argues, be even larger than required. After the first expense, the farmer, he says, would be put to no expense but that of maintaining the roof of his cistern and the conduits leading to it. It must be admitted that the rain water lost, or worse, allowed to ruin the foundations of houses in the country, might and should be economised, but the furnishing and maintaining in serviceable condition a complete set of eave and conduit pipes, to say nothing of the reservoir itself, would entail an expenditure which, to small farmers, such as exist in France by hundreds, men possessing the extremely small quantity of land mentioned above, would be something terrific if not impossible. Still, the subject deserves attention, and applies equally to England as to France or Venice, and M. Grimaud de Caux is conferring a service on society by his examination of the subject."

Water-tank.—*Waistell's Water-tank* is thus described in Loudon's Encyclopædia of Villa and Cottage Architecture:—"It is circular in the ground plan, with the sides built like a wall. The bottom should be in the form of a flat dome reversed, and the top also domical, with an opening left in the centre of sufficient size to admit a man to clean it out occasionally; the top of this opening should be a little above the surface of the ground, and should be covered with an oak flap, with several holes bored in it for ventilation; or the cover may be an iron grating, horizontal, and a little elevated or conical. These tanks may be constructed of various dimensions; the depth and width should be nearly equal; a hole should also be left for the service-pipe, or that which conveys the water into the tank, and also for the pipe for the pump, if the water be drawn out by that means. The water may be filtered previously to its entering the tank; the hole for the service-pipe ought therefore to be near the top, and on that side most convenient for the filtering chamber; this may be about 4 feet in diameter and 3 feet deep; across this, about 12 inches from the side next the tank, as at fig. 118, *l*, a slate partition, from the top to within about 6 inches from the bottom, should be fixed ; at the bottom of the box should be put clean coarse sand or pounded charcoal, about a foot in thickness. The pipe or opening from the filter to the reservoir should be of ample dimensions, and be made at about 18 or 20 inches from the bottom, in the small division or space behind the slate. Above this opening, and in any part most convenient, * * * in the large division of the filter, should be an opening or drain to carry off the water when the tank is full. This filter should also have a cover, that it may be cleaned out, and fresh sand or some other purifier put in as often as may be found requisite. Of course, the water, as it comes from the roof, is to be first conveyed into the large division of the filtering chamber, on the opposite side to the slate partition, * * * and passing through the sand, it rises in the small division purified, when it is fit to pass into the tank by a tube. If there are two or more of these filtering chambers, or if they are of greater depth, the water may be passed through the greater quantity of sand, &c., in them, and be still more purified. Both the tanks and the filtering chambers should be water-tight ; if constructed of brick, the inner course may be built in Roman cement, and afterwards the whole of the inside covered with a coat of about ¾ths of an inch thick of the same material. Water from drains formed in the ground for the purpose of collecting it for domestic purposes, may be purified by passing it through a sand filter previously to its entering the tank or reservoir. Sponge or flannel may be used as filters. In constructing tanks of the above description, care must be taken to have the earth closely filled around the brick-work, and to allow sufficient time for the work to get properly settled previously to admitting any great weight of water. Cisterns for water formed of blue slate or Yorkshire paving stones, are much better than those made of wood and lined with lead."

SECTION THIRD.—TERMS USED IN BRICKLAYING AND MASONRY.

Abrevoir, the junction of the faces of two superimposed stones.

Alcove, a niche or recess made in a wall.

Apertures (also called *voids* in Scotland), openings made in the wall for windows or doors. If they are circular headed, and a number are placed in line, the arrangement is called an *arcade.*

Arch.—That part of a building which stretches over an opening. In fig. 42, Plate D, we give an illustration of an arch. The lower or internal line or curve *a b* of arch is called the *intrados;* the external line, which may either be parallel or not to the intrados, as E A B, is the *extrados;* the central stone B is called the *key stone;* the wedge-shaped stones, as A, the *voissoirs;* the *abutment* is at E C; the *filling in at the haunches* at B. Arches in house building are of different kinds, as :— *Gauged Arches* have their intrados in several pieces, radiating from a centre, see annexed fig. 1. *Invert Arches* are illustrated in fig. 43, Plate D, and are principally used in basement stories under openings. *Relieving Arches* are run over lintels or bressummers, placed at the head of openings in the wall, in order to ease them of the superincumbent pressure.

Fig. 1.

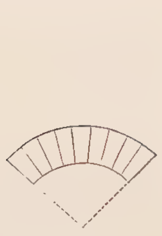
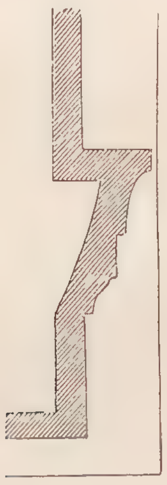


Fig. 1*a*.



Archivolt.—The assemblage of mouldings which run round an arch is so called, see fig. 1*a*; it is also sometimes termed an architrave, which see under Section Fourth.

Ashlar, the facing of hewn and dressed stone given to walls, the back of which is of rubble (which see).

Bass.—The trough used to contain mortar, or tiling, &c., is so named.

Fig. 2.

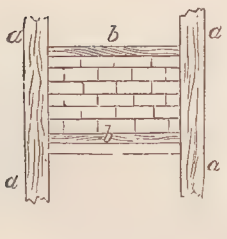
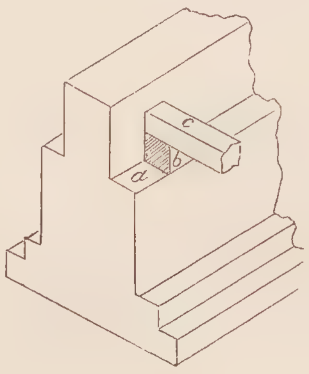


Fig. 3.



Beam-filling.—Filling in with stones or bricks between beams, rafters, &c., as between the beams *a a* and quarters *b b*, fig. 2.

Bearing Wall.—A wall constructed to support another part, as the wall *a* in fig. 3 to support the beam *c*.

Balcony.—A projecting gallery supported on trusses.

Baluster.—A small round pillar belonging to a balustrade, either in wood or stone, as fig. 4. A range of balusters is termed a balustrade.

Batterdean, another name for a *Cofferdam.*—A case formed of piles, water tight, to exclude the water while building the piers of a bridge (see *Foundations in Cofferdam*, figs. 39, 40, and 41, Plate D).

Fig. 4.

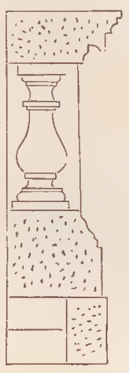
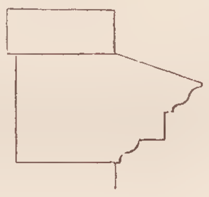


Fig. 5.



Bed.—The upper and lower surfaces of a stone are called the bed.

Bedding.—The term used to denote the placing of the various timbers of a building, as sash and door frames, which rest upon the brick or stone work in lime and hair mortar.

Blocking Course.—A massive course of stone (see fig. 5) placed on the top of a cornice, to give, by its weight, stability to the wall.

Bond is the overlapping of stones or bricks upon one another, as to form a compact and inseparable mass. In brickwork Bond is of two kinds, *Flemish Bond* and *Old English Bond. Flemish Bond* is that in which every course formed with a header, *b*, fig. 6, and stretcher, *a*, fig. 6, alternately (see "Header" and "Stretcher"). *Old English Bond* is that in which every alternate course is made up of headers *b b*, and the other courses of stretchers *a a*, fig. 7.

Fig. 6.

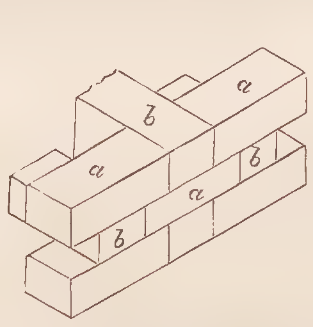
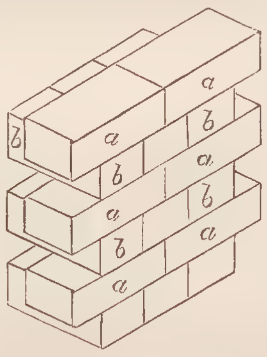


Fig. 7.



Breaking Joint.—Where the solid part of a stone, as *a*, fig. 9, is placed over the vertical joint of two stones placed below, as *b* and *c*, the stone *a* breaks joint with *c* and *b*.

Fig. 8.

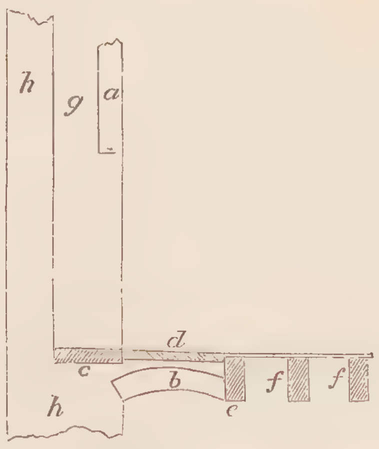
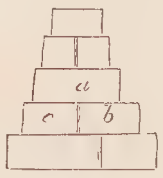


Fig. 9.



Breasts of a Chimney.—The solid part of the wall between the flues and the rooms, as the wall *a* between the room and the flue *g*, fig. 8.

Brick-nogging.—This term is used when a partition is constructed with a row of quarters, *a a* (see fig. 2), placed about 3 feet apart. The spaces between the quarters are filled in with brick-work, which is bonded or tied to the work by "nogging pieces" *b b*, laid horizontally every 2 feet, nailed to *a a*.

Camber.—An arch, a lintel, or a beam, placed over any opening, is so called. The term is also used to denote the rise or curve upwards of a trussed beam thrown over a wide opening, which upward curve is given to counteract the pressure tending to make the beam sag or lower in the centre.

Cavetto.—A hollow moulding (see *Mouldings*).

Chimney.—When a number of flues are built in the wall, the part carried above the roof is called a stack of chimneys. The term is also used to denote the aperture made in the room in which the fire-grate is placed. Fig. 8 shows a section of a chimney; *a* the *breast; the front hearth-stone d* is supported upon an arch *b* called a "*trimmer arch;*" *c* the *back hearth; g* the *flue; e trimmer beam; f f joists.* The division between two flues, as *b c*, fig. 10, is called a "with," as *a a.*

Cill.—A stone fixed at the bottom of a window aperture; cills project about 2 inches beyond the face of wall, and are what are called *throated*, as at *b*, fig. 11, which catches the water, causing it to drip, and preventing it from passing to the wall. The upper part of cill *a* is made sloping, which is termed *weathering* or *sunk*.

Fig. 10.

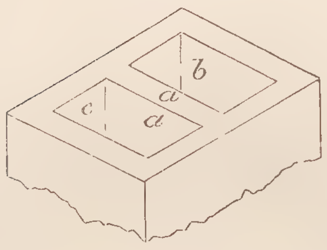
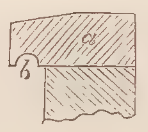


Fig. 11.



Closure, or Closer.—The last brick used to terminate the length of a course; it is usually a part of a brick.

Coping.—The upper course of a wall. This is sometimes made of bricks placed on edge, called *Brick on edge work*, but in better class work is made of stone, either flat, as at *a*, in fig. 12, termed *parallel coping*, or as at *b*, termed *feather-edged coping*, or as at *c*, which is termed *saddle-backed coping*.

Fig 12

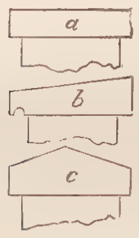
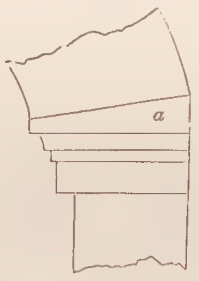


Fig. 13.



Core.—When a projecting part is required to form a cornice in plaster or cement, the internal part formed of bricks or tiles is so called.

Cornice.—The moulded projecting part finishing a wall, &c. (see fig. 5).

Cousinet.—The upper stone *a* (see fig. 13), or impost, which receives the first voissoir of an arch, the upper face of which is sloping, as shown in diagram.

Dado.—The part between the base and cornice of a deep skirting-board of a room.

Die.—The part between the base and cornice of a pedestal.

English Bond.—(See *Bond.*)

Extrados.—(See *Arch.*)

Flues.—Vertical tubes formed in walls for the conveyance of smoke from the fire-places, as *b c* in fig. 10.

Footings.—The lowest courses in a wall, spreading beyond thickness of same to obtain a more solid foundation, as in figs. 3 and 9, and in fig. 44, Plate D.

Gable.—The triangular termination of the end wall of a building.

Gathering.—The diminution of the funnel or flue above the fire-place.

Gauged Arches.—In these the bricks radiate to a centre, as in fig. 1.

Groin.—The hollow formed by the intersection of vaults crossing at equal heights.

Hacking.—In defective work this arises in cases where the stones are not of equal depth; the beds are on a different level, the defective course being made up of two courses, as *d d, e e*, in fig. 14.

Headers.—Bricks or stones placed in a course in the direction of the breadth or thickness of the wall, as the brick *a* in fig. 15.

Hollow Wall.—A wall not solid in the direction of its thickness, but provided with a cavity or hollow space *b*, fig. 16, between the inner and outer shells *a a*, fig 16.

Fig, 14.

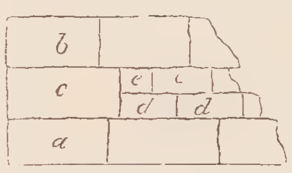
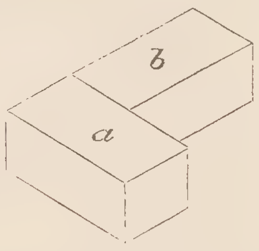


Fig. 15.

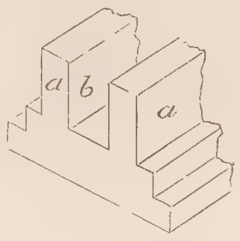


Impost.—The upper part of a wall or pier from which an arch springs, see fig. 17.

Intrados.—(See *Arch.*)

Jambs.—The vertical sides, *b b*, of an opening in a wall, as *a a*, fig. 18.

Fig. 16.



Fig, 17.

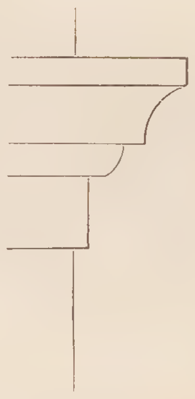
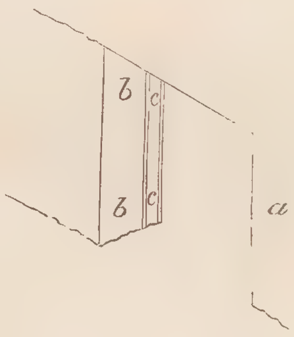


Fig. 18.



Joggled Joints.—When two blocks, as *a b*, fig. 19, are prevented from separating by the placing of the dovetail piece *c c*, the joint is said to be "joggled."

Keystone.—(See *Arch.*)

Lewis.—A contrivance used for raising heavy stones. In the upper side of the stone *a a*, fig. 20, a dovetail *b* is cut; the *lewis* is made up of three parts—the central part *a a*—to the eye of which the hook of the lifting chain is connected—and the two side pieces *b b*. These are inserted in the dovetail hole *b*; and then the central part *a a* is inserted, and the whole secured by the bolt *c c*.

Fig. 19.

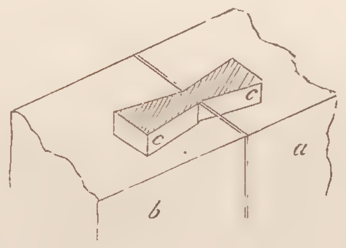
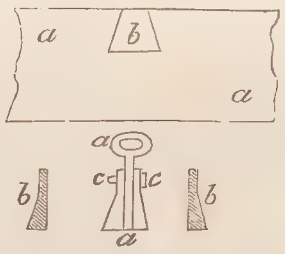
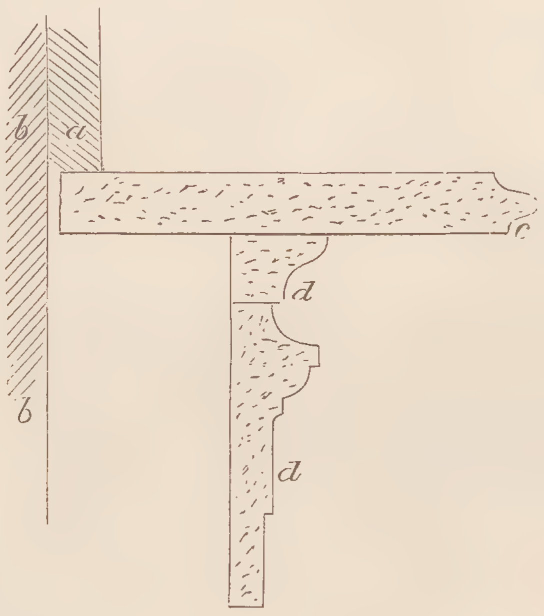


Fig 20.



Mantlepiece Shelf.—In fig. 21 this is illustrated. *a* the plastering in front of the chimney breast; *b b* the brickwork of ditto; *c c* the mantle shelf; *d d* jambs of chimney or mantlepiece.

Fig. 21.



Mouldings.—*Fillet*, or *Listel*, fig. 45, Plate D, is a small member consisting of two planes at right angles, used to separate two larger mouldings, or to form a cap or crowning to a moulding. The intervals or small bands between the flutes of a column or other body are termed fillets. *Astragal*, or *Bead*, is a moulding having usually a semicircular section projecting from a vertical diameter. It is frequently applied not only at the upper end of the shafts of columns, but likewise in their bases and entablatures. Fig. 46, Plate D, *Greek Astragal.* Fig. 47, Plate D, *Roman Astragal.* *Cyma-recta*, or *Cymatium*, is the uppermost moulding or member of a cornice, the profile of which is waved, being concave at top and convex at bottom; and the section of which is usually a curve of contrary flexure. Fig. 48, Plate D, *Greek Cyma-recta.* Fig. 49, Plate D, *Roman Cyma-recta.* *Cyma-reversa*, or *Ogee*, is a compound moulding, being convex at top and concave at bottom, consequently the reverse of a cyma-recta. Fig. 50, Plate D, *Greek Cyma-reversa.* Fig. 51, Plate D, *Roman Cyma-reversa.* *Echinus*, or *Ovolo*, a convex moulding much employed in cornices, and in the Doric and Ionic capitals, and usually having ornaments carved thereon representing eggs. In the Roman examples it is most frequently a quarter of a circle. Fig. 52, Plate D, *Greek Echinus.* Fig. 53, Plate D, *Roman Echinus.* *Cavetto*, or *Hollow*, is a concave moulding or cone used principally in cornices, the curvature of the section of which does not usually exceed the quarter of a circle. Fig. 54, Plate D, *Greek Cavetto.* Fig. 55, Plate D, *Roman Cavetto.* *Scotia*, or *Casement*, is a recessed moulding of an elliptical or circular section, placed between the upper and lower torus in the bases of columns. It is called also *trochilus.* Fig. 56, Plate D, *Greek Scotia.* Fig. 57, Plate D, *Roman Scotia.* *Torus*, or *Tore*, is a moulding having usually a semi-circular or semi-elliptical section, used in the bases of columns. Fig. 58, Plate D, *Greek Torus.* Fig. 59, Plate D, *Roman Torus.* *Apophyge* is the section of a moulding partly concave and partly straight, and is used in the Ionic and Corinthian orders for joining the bottom of the shaft to the base, as well as to connect the top of the fillet to the shaft under the astragal, as fig. 60, Plate D. *Annulets* are the fillets between the hypotrachelion sections of a Doric capital. In the Roman Doric order, they are usually three in number, and of equal size, with rectangular sections, (fig. 62, Plate D.) In the Grecian examples they vary from three to five. Fig. 61, Plate D, *Grecian Annulet.* Another kind of *Annulet* which has a vertical position. This form (fig. 62, Plate D), is only to be found in the Doric portico at Athens. A curious *Grecian moulding* to be found under Coronas, fig. 63, Plate D. *Mouldings Raking*, fig. 64, Plate D.

Natural bed of a Stone.—The position in which the stone lies in its natural condition; it is also called the *quarry bed.*

Offset.—When a wall *b b*, fig. 22, is not of equal thickness throughout; but one part set back, the top surface of the part so set back, as *a*, is called the offset.

Perpend-stone.—A stone which stretches right across the thickness of a wall.

Quoin.—A corner pier. Quoin stones, *a a b*, are shown in fig. 23; these are called rustic stones when they project from the surface of the wall, and have their edges chamfered or bevelled off.

Fig. 22.

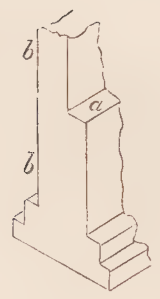


Fig. 23.

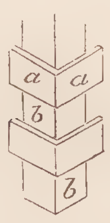


Fig. 24.

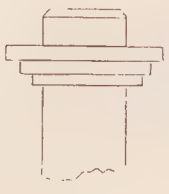
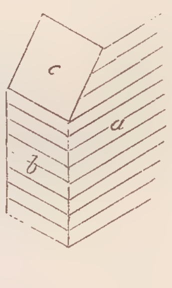


Fig. 25.



Reveals.—The sides *b b*, fig. 18, of an opening in a wall, *a a*, between the front edge of wall, and the outer side of door or window frame *c c*, fig. 18.

Sailing Courses.—The courses of bricks projecting from a wall or chimney stalk, as in fig. 24.

Skew-back; the raking surface *c*, fig. 25, of wall *a b*, from which an arch springs, is so called.

Sleeper Walls; walls carried up, as *a*, fig. 3, to support joists *c*; *b* the wall or joist plate.

Splayed.—Where the corners, as *a*, fig. 26, of a brick are cut off at an angle, the brick is said to be splayed; they are used at the external angles of door jambs.

Stretchers.—Bricks placed in the direction of the length of the wall, as *b*, in fig. 15.

String Course.—A projecting course, plain or moulded, carried round the wall at a certain height. Fig. 27 shows a string course at level of window.

Fig. 26.

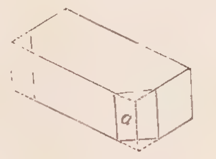


Fig. 27.

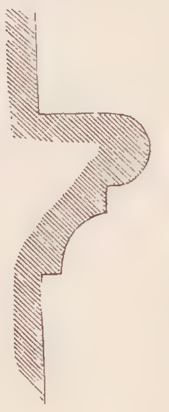
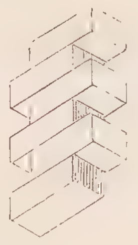


Fig. 28.



Toothings.—Where a wall is stopped short, but likely afterwards to be continued on the outer edge, is left rough, with projecting parts to form a bond with the continued part, as shown in fig. 28.

Trimmer Arches.—Flat scheme arches turned at fireplace to rest front hearth upon; see chimney and fig. 8.

Withs.—The solid divisions which are placed between flues are so called, as *a*, dividing the flues *b* and *c* in fig. 10.

PRACTICAL NOTES AND MEMORANDA UNDER SECTION THIRD.—BRICKLAYING AND MASONRY.

(1.) *Weight of Brickwork.*—A brick of the standard size weighs 4 lb. 15 oz; 1,000 will weigh 2 1-5th tons. A rod of brickwork weighs 13 tons.

(2.) A rod of brickwork, 1½ brick thick, is 272 superficial feet. To build this it will take 18 bushels of stone lime, and 3½ "single loads" (see par. 1. Notes to Section Second) of sand. If cement is used, 36 bushels with the same quantity of sand will be required. All brickwork is measured by the above standard, and is termed the "standard of reduced brickwork." *To reduce any given amount of cubic feet of brickwork to the standard*, multiply by 8 and divide by 9. A standard rod of brickwork will take 4,500 stock-bricks—allowing 16 bricks to each foot.

(3.) *Paving Bricks.*—Thirty-six bricks laid flat, and 52 on edge, will make one yard of paving. A paving brick weighs 3 lbs. 13 oz., and measures 9 inches in length, 4½ in width, and 1¾ in thickness. A foot paving tile is 11½ inches square, and 1½ in thickness; and 9 will pave a yard.

(4.) *Lime—Sand—Mortar.*—A cubic yard of *lime* contains 21 bushels; 8 gallons go to the bushel, and 227¼ cubic inches to the gallon. Twenty-five bushels of lime when heaped will form a heap or mass of three feet square in surface, with a depth of 3 feet 6 inches. A cubic yard of *sand* is a single load, and amounts to 18 heaped or 21 stretched bushels. Twenty-seven cubic feet of *mortar* is a load. A bushel of mortar contains two hods, and will lay about 50 bricks.

(5.) *General Sanitary Rules in connection with Drainage and Sewerage.*—"There are some general rules," says Mr. Rawlinson, in reporting upon the sewerage of Windsor Castle, "necessary to be observed in devising entirely new sewerage works, which cannot now be made applicable to Windsor Castle. I name this because an approval of work done might otherwise be taken to imply that it would be proper to follow, in other cases, that which exists at Windsor Castle, whereas nothing better could, under existing circumstances, be accomplished.

"As a rule, sewers should not enter any inhabited building, and all drains should commence at the outside walls, and not traverse the floors of the basement.

"All water-closets should be in connection with an external wall, and have a fixed amount of external light and means for unceasing ventilation.

"All rooms, to be inhabited, should have external sunlight.

"All sewers and drains should have full and free external ventilation, and gases escaping being made to pass through wood charcoal filters.

"Cesspools should not be in existence within or near any dwelling. Manure-tanks can only be allowed for agricultural uses, and these should never have any direct communication with sewers or with house drains.

"An elevated site (like Windsor Castle) offers a good fall for water and for fluid refuse, but also offers facilities for the rapid upward flow of sewage gases. It is therefore advisable to break the gradient of any steep sewer or drain at intervals, and cut off by a flap-valve and full ventilation all chance of gases rising from the lower levels to the buildings and rooms at the highest points.

"If sewers and drains traverse the basement of any building, such sewers and drains should be absolutely air-tight within the external walls, and no untrapped internal communication should be allowed with any sewer or drain.

"The sub-soil beneath any inhabited building should be dry and sweet, because at all times, when the internal temperature of the air is greater than the external temperature, or than the temperature of the subsoil and the sewers, the rooms exert a sort of pumping power; so that a foul subsoil, in which are foul cesspools, sewers, and drains, may give off gases sufficient to contaminate the entire body of air within any building, if such influence is not made impossible, and if a full admission of pure air is not provided for.

"A natural watercourse should not be inclosed and converted into a sewer, because the volume and flow of water down a brook or rivulet is very irregular, varying as much as 1 to 300; that is, the dry-weather flow of a stream being represented by 1, the wet-weather flow or 'flood' may be represented by 300."—Mr. Rawlinson.

(6.) *Prevention of Damp in Walls.*—"There are various ways of preventing damp rising in walls. We have ourselves, with very satisfactory results, inserted two or three courses of slate in cement. It should be below the level of the lowest joists, and the wall should be further protected by a properly ventilated and drained dry area. Sheet-lead in place of slate is in some cases more efficacious, but is at the same time more costly. The insertion of three courses of slate is not by any means expensive."—*Building News.*

(7.) *Floor for Cattle Stalls: H. P.* "Asphalte flooring has been recommended.

We give," says a practical Journal, "the following recipe, not on our own experience, but on that of a correspondent 'J.P.B.' who says, 'Dig sifted gravel, such as is used for topping walks, and use coal-gas tar; level the ground perfectly; mix gravel and tar, two quarts of the latter to each bushel of the former, till every particle of gravel is saturated with tar. This is best done on a boarded or stone floor; spread evenly, about one inch thick; roll till hard with a heavy garden roller. When dry, add from two to five inches more, according to the purpose for which the floor is required. Roll as soon as laid, and frequently until it is quite solid. Cost, at 6 inches deep, 9d. per square yard, at the following high prices:—gravel, 1d. per bushel; gas tar, $4\frac{1}{2}$d. per gallon; labour, 1s. 6d. per day.'"

(8.) *Mr. Carey's Plan of Road-making.*—"The entire bed of the macadam is taken up, the material twice screened; the first, by $1\frac{1}{4}$-inch sieves, selects the larger lumps of the broken Guernsey, and this is reserved for use again in the surface strata. The second screening, by $\frac{1}{2}$-inch sieves, brings out a stone of smaller size. The rest (dirt and stone ground to powder—about half of the whole mass) is carted away. A sub-stratum, composed of broken Kentish rag with small stone (the second screenings of the old material), and an ingredient formed of coal-tar and ashes, the whole moistened with water and well blended, is laid down and carefully formed to the intended shape of the road, and brought to a smooth surface by rolling. This forms a compact, tough, and elastic layer, impervious to water, and constitutes what may be appropriately termed the cushion—the primary feature of originality in Mr. Carey's plan. On this lies the super-stratum, which latter consists of a 4-inch layer of the cleaned Guernsey. The top is sprinkled over with a small shingle of the same material—wedges, as it were, for binding the surface stones together; and over that another sprinkling of a fine loamy gravel, these together partially filling up the interstices of the lumps of stone. Then, by the application of a heavy roller, a smooth surface is obtained previous to the traffic going on. The contract for this work is 2s. 6d. per square yard.

"Connected with this work is an original feature, in the introduction of an iron gutter or channel. This is formed of plates of iron, 16 inches long and 4 inches deep, and bolted into each other. They are set in cement. The width is 16 inches, the surface somewhat concaved and ingeniously corrugated, so as to prevent slipperiness, and at the same time afford the requisite facility for cleansing. The cost of this gutter is 4s. per foot."

(9.) *A Material for Road-making.*—"A new system of road-making has just been substituted for the ordinary roadway on a part of the Place du Palais Royal, at Paris. A quantity of concrete, about 5 inches in thickness, is first spread out, and on that is applied a layer of bitumen reduced to powder, and in a boiling state. On this latter, which is also about 5 inches in thickness, a quantity of river sand is sifted, and then the surface is pressed down by a heavy cast-iron roller, weighing about 2 tons. In a few hours after the road thus made may be passed over by the heaviest waggons without the slightest impression being left by the wheels. The same system is now being applied to part of the Rue St. Honore, comprised between the Palais Royal and the Rue de Richelieu, and in the latter street as far as the end of the Théâtre Français."—*Builder.*

(10.) *Asphalte for Foundations.*—A correspondent of a professional paper gives the following on this subject:—"In a case that came lately under my observation, where the soil was treacherous, a trench of about 4 feet in width, and 3 feet 6 inches in depth, was dug: into this trench was rammed 2 feet of concrete: upon the concrete pounded slag was laid to a depth of 6 inches, and bitumen was run over it: two more layers of the same thickness, but of a less width, were laid in the same manner; and upon this foundation the stone and brick walls were erected."

(11.) *Strength of Asphalte.*—"At 19 tons 2 cwt. one of the bricks cracked: at 36 tons to 38 tons the *bricks*, jointed with asphaltic lava, crumbled on the edges, and the *cement* joints cracked: at 48 tons the asphaltic lava *joints* held good and perfect when taken out.

"Further, asphalte when properly made, and well applied on foundation-walls, will prevent the rising of damp; and its durability is known to withstand different temperatures."

(12.) *Concrete for Foundations in Bad Soil.*—"It was found desirable to erect a dwelling in the marshes near Ware, Herefordshire, where the soil was of so bad a nature that piles could be driven to any distance without finding a solid bottom; it was therefore resolved, in order to avoid fractures, to adopt the method common in that neighbourhood, of building the house upon planks laid on the ground, under the impression that all would go down together. This was accordingly done, but the house being of some extent, it was found impossible to preserve an uniform pressure upon all parts of the foundation, and the building split in various directions, and was ultimately taken down as unsafe. The necessity, however, for the erection remained; and after some deliberation as to what could be done, it was determined to form a concrete sub-stratum for it; an excavation was therefore made, about 6 feet wider on all sides than the intended base of the house, which was about 40 feet square, and to a depth of 7 feet; farther down than that they could not descend on account of the water; and a pile could be driven almost to any distance into it. A concrete compounded of stone lime and silx was thrown in, in layers of 6 inches, each succeeding bed decreasing. The amount of lime used was one-sixth the quantity of the material. One month was allowed to elapse, so that the mass might become solid, and then the house was erected. It has now stood more than three years without the slightest settlement or division. The whole remains precisely as much above the ground as when first constructed, the concrete sub-stratum having served, as Alberte says, speaking of foundations generally, like a wide shoe does to those who walk upon the snow."—Mr. Godwin on "Concrete."

Concrete.—In preparing concrete, the following proportions have been found to succeed perfectly in some recent structures:—

Hydraulic lime (unslaked), ...	0·30 parts.
Sand (middling), ...	0·30 ,,
Cement (common clay), ...	0·30 ,,
Gravel (coarse), ...	0·20 ,,
Chippings of stone, ...	0·40 ,,

The lime, sand, and cement, are, in the first place, thoroughly worked up into a homogenous mass of a hard temper; this mass is suffered to rest in a heap about twelve hours, it is then spread out into a layer about six inches thick, and the gravel and stone are evenly spread over it, and the whole well mixed up. The mass, before it is used, is suffered to remain until it has partially set, which will require from twelve to thirty-six hours, according to the quality of the mortar. This delay is found to improve the quality of the concrete. This material depends on the quality of the mortar for its excellence. It is not stronger than simple hydraulic mortar, but it is far more economical. The gravel which enters into its composition is used to fill up the voids between the fragments of stone, which would otherwise be filled by the mortar alone. Broken brick may be used instead of fragments of stone when the latter cannot be had; or gravel alone may be used.

(13.) *Thick and Thin Beds and Joints in Brickwork and in Masonry.*—On the above subject Mr. R. Rawlinson, the well-known sanitary engineer, has written the following to the "Builder:"—"The use of thin or of thick beds of mortar, in brickwork and in masonry, must, in a great measure, be governed by the character of the work and the quality of the materials. Marble, if moulded, carved, and even if plain, but polished, must have fine beds and joints. Ashlar masonry, as in the New Houses of Parliament; in the Reform Club, Pall Mall; in St. George's Hall, Liverpool; and, in all masonry of this class, must have thin beds and joints. The best class of brickwork and terra cotta work, plain or enriched and moulded, must also have thin beds and joints. As a general rule, it may be stated that buildings, whether of marble, of limestone, of sandstone, or of brickwork alone, or of brick and terra cotta combined, which are ornamental in character, enriched by carving and mouldings, or plain on surface, but polished or tooled, must all have thin beds and joints. Thick beds and joints of mortar would destroy the harmony of design, by deteriorating the appearance of labour bestowed on the marble, stone, or brick and terra cotta, in such buildings.

"The Romans used 'tiles.' That is, Roman bricks are (many of them) square, like tiles, say 6 inches by 6 inches, or 9 inches by 9 inches, or 12 inches by 12 inches, and 1 inch, $1\frac{1}{2}$ inch, or 2 inches thick. In many Roman buildings now existing such bricks or tiles may be seen, set in beds of mortar almost of equal thicknesses to the tiles. In the East generally (Constantinople), as also in Spain and in Italy, this class of work exists, in ancient buildings, as likewise in those most modern. Tanks, towers, minarets, domes, arches, and walls, may be examined, in which bricks and mortar have almost equal proportions. Where the mortar is good, such buildings are sound after centuries of wear, neither the action of the elements nor the violence of man having wholly destroyed them.

"In modern practice, in all masonry and brickwork, where strength is required rather than ornament, thick beds and joints, of good mortar, will be useful. Thin bricks or tiles will also be better than thick bricks, as the material will be better burned, and consequently more enduring; more mortar can also be used, which, in such work, gives strength.

"Mortar may be used safely, and even with advantage, in thick beds and joints in masonry, for docks, for railway bridges, viaducts, and retaining-walls, as also for warehouses, goods' stations, cotton-mills, tall chimneys, fence-walls, and all similar structures. Reservoir walls, tank walls, and covering arches for water-works, ought most certainly to have thick beds of good mortar.

"The proportion of mortar to rubble stonework should be about 1 to 3, that is, in 4 cubic yards of rubble wall there should not be less than 1 cubic yard of mortar. In brickwork (ordinary bricks) the proportions will be 1 to 4. If thin bricks are used, or if very small stone is used for rubble work, the proportions may be as 1 to 1, like some of the work to be found at this day in Italy and in the East, which ancient work is sound after centuries of time; and all the destructive agencies of the elements, of man, and even earthquakes, have failed to destroy such work in many instances.

"Much may be said as to the disadvantage and danger of building hybrid work—that is, injudicious mixtures of ashlar, rubble, brickwork, and concrete. But a treatise would be required, illustrated by many diagrams, fully to detail all that may be said on this most important part of masonry."

(14.) *On the Employment of Stone as a Building Material for Factories.*—Mr. Kennedy says:—"If we look first at the suitability of stone for the purpose, there can be little doubt that it is the very best possible if used in the form known as cube materials, as the bed joints, being all horizontal, there is little, if any, tendency in the stones to shift; and it is also a very simple process to make the proper arrangement for building in and securing the wheel fixings, or whatever kind of fixing may be required, as stones can be easily brought to the shape required to fit the metal, and bolt holes can be made with certainty in the required position. But if we take rubble or ashlar walls, then the case is very much altered (although in some localities there is no alternative but to build rubble walls, and there are many such buildings, yet it is by no means a system to be adopted if it can be avoided), as the stones are of every conceivable shape, the joints are in very few cases either horizontal or vertical, and even the headers that are intended to strengthen the wall by binding the two faces of it together, are seldom anything like square stones, making the wall depend in a great measure for its stability on the cohesive power of the mortar, which takes years to set properly, whereas the machinery is put up at the first, and by its vibratory motion, has a powerful tendency to disintegrate the building, and thus prevent the mortar from ever setting in the best manner. And if this be the case with rubble walls, it can scarcely be said to be improved with ashlar, as, from the system pursued in preparing the ashlar in the quarries, the stones are reduced to a thickness that makes the wall little else than two thin walls, the one ashlar and the other rubble, held together by the mortar, and the rybats of the doors and windows; no doubt this could be improved by making the ashlar stones more nearly resemble cube work, and the stones for the rubble of such a size and thickness as to work in course with the ashlar, but this would very much increase the cost, which is altogether unnecessary while we can take brick as a building material."

(15.) *Strength of Stone Steps in Geometrical Staircases.*—Mr. Paterson writes to a public print on this subject, from which we extract the following:—"To make the whole area of steps and landings composing a stone stair of equal strength throughout, it is quite requisite that every stone should be at least 1 inch thicker or deeper at the wall-hold for every foot it projects from the face of the wall than what it is at the nosing at the well-hold. This is done by having the rebate of the steps of an extra depth down to the soffit, as no difference will take place so far as the height of the breast of the step is concerned. The wall-hold of both steps and landings should not be less than equal to one-seventh part of the projection from wall to nosing of well-hole."

(16.) "*The names of the bricks in general use in our modern works are*—Gray stocks, red stocks, washed stocks, place bricks, marls or malms of two qualities, called first and seconds, red rubbers or cutting bricks.

"The *gray stock* is the most useful brick we have—made of good earth and burnt; it is well adapted for any work where strength and durability is required, as in external walls, counter or discharging arches, piers or underpinning, and forms a very good front when carefully selected of a uniform colour.

"The *red stock*, which is so freely used now in the fronts of our modern structures, is made of a clay containing much oxide of iron. The finest description of this brick, made from the purest clay, is called a red rubber or cutting brick, used only for gauged arches and very superior work.

"The *washed stock* is made of a purer clay than the common stock, is of a yellow tone, and equivalent in appearance to the marl's seconds for facing of fronts.

"The *place brick* consists of half-burnt clay, and consequently what is termed sammel or soft, is of a dark red colour, and readily crushed and crumbled; of late years the place bricks have been so exceedingly bad that, in my opinion, they are worthless as a brick, and only fit to be broken up and used as burnt clay for paths or beds for pavings, drains, &c., and should strongly recommend the rising members of the profession to prohibit the use of them in their specifications.

"The *marl* or *malms*, as they are sometimes called, are fine, yellow toned bricks of two qualities, firsts and seconds, both of which are much used as facing bricks. There is another description of malms, a harder degree of brick, used for the purposes of paving, and called malm paviors. There is another description of bricks, called Dutch clinker, which are exceedingly hard and vitrified, are sometimes used for paving stables and yards, but more frequently for building ovens or furnace work, but the best bricks for such purposes are what are called fire-bricks; they are chiefly made at Hedgerly, and hence they are known by the name of Hedgerly bricks.

"There are two more description of bricks worthy of notice, which of late years have been extensively used in our modern structures.

"The first, the fine white brick made in Suffolk, and denominated White Suffolks, expressly made for facings; some have of late been introduced in moulded forms, which form, when judiciously treated, forms a very pleasing effect in window dressings, strings, and cornices, superseding the necessity of cutting and rubbing bricks to splays and other forms, which, while they look well to the eye, the process of cutting and rubbing injures the brick as an external material, as the crusting or outer surface of a brick is more durable than the interior, and therefore better calculated to withstand the ravages of time, particularly in our changeable climate.

"Again, the moulded bricks in window dressings, strings, and cornices, are superior in appearance and durability to cement dressings, and I have no doubt, when they become more generally known and more extensively applied, that they will altogether supersede cement mouldings, for the greater the demand the cheaper will the manufacturer be able to supply them.

"Last, but not least, are the patent machine-made perforated bricks, invented by a person of the name of Beart; hence they are known by the name of Beart's Patent Bricks, and they are readily moulded, at a very moderate expense, to any pattern or drawing you like to send them. They are not equal in appearance to the White Suffolk brick, but much cheaper, and in that case a desideratum when the question of expense is to be studied. Burrs do well for foundations, being often as hard as clinkers. The lecturer then proceeded to refer to mortars, including those composed of chalk lime, stone lime, Dorking sand, Thames sand, pit sand, and road grit, and to their being well tempered and beaten with a mortar beater. When the materials are well mixed, employ the composition quickly, as the least delay may render the application imperfect or impossible."—*Professional Paper.*

(17.) *Comparative Advantages of Thin and Thick Bricks.*—"It is well known," says Mr. Kennedy, "that the majority of them are about $3\frac{1}{2}$ inches thick, some of them more, thus making the height of each course nearly equal to the width of a brick, which not only looks bad, but also weakens the stability of the walls. This weakening arises, not only from the height of the course, but also from the fact that all the softer bricks are built in the inside, and more particularly in the heart of the walls; and as they are always thicker in proportion to their softness, it is easy to see that this produces the very reverse of what is necessary to constitute a stable building, as the bed-joints through the wall, instead of being level, are more frequently round, thus giving the wall a tendency to topple, which is only met by making the lime-beds thicker for the outside course than for the heart of the walls. There is another imperfection which results from making the bricks so thick, viz., that they are apt to become more distorted by the burning, which not only makes it more difficult to get a straight surface for the walls, but also compels the general average of the bed joints to be kept thicker than would otherwise be the case, so as to keep the bricks from touching each other. No one who has buildings, in which the bricks are only about $2\frac{3}{4}$ in. thick, and the bed of lime not more than $\frac{1}{4}$ in. thick, thus making each course 3 in. thick, but must have been pleased with the decided superiority of their appearance. Such bricks possess, in addition to this, the advantage of being more likely to be evenly burnt, and also of there being much less difference of thickness between the hard and the soft ones, thus enabling the walls to be built with a thinness of bed joints not attainable at present, although always required in the specifications issued. It is with no small satisfaction that I observe various brick-makers are in favour of reducing the thickness of the bricks, as indicated by the movement they have made and the expense they have incurred in their endeavour to get machines to make a superior article, and also to make the red and the fire brick the same thickness, so that they may build in the same course."

(17.) *Chimneys and Flues.*—Mr. Joseph Glass, of Brixton, has forwarded us some observations on the construction of flues, with a view to obtaining the avoidance of slants and horizontal positions, so as to permit the efficient working of the chimney-sweeping machine, with a view to the disuse of climbing boys. He says:—

"To render buildings safe from fire, much depends on the construction of the flues: for instance, if the flues are made perpendicular, or nearly so, and without angles or lodgments, in this case there would be little or no danger: on the contrary, when flues are made in an angular form, some parts being horizontal, and which are designated by the climbing boys 'dead slants,' in this case the building cannot be pronounced safe. It will be found that, whatever means are adopted to sweep these flues, much difficulty will arise in clearing them properly, although the parties employed may use their best endeavour to do so. In the examination of flues of this description, I have found a considerable quantity of soot collected at these angles and slants after being swept by the climbing boys. The only effectual plan is to introduce a soot-door into the side of the slant, when the slant and angle could be properly cleaned. But this is attended with inconvenience to the parties concerned, and would not at all be required if flues were made in a proper manner; and there can be no reasonable excuse why flues should not be made so in the construction of buildings in future. A deposit of soot lodged at an angle is not unfrequently ignited by a single spark, and may smoulder for hours and days together, till the whole is ignited; and, as the heat increases in intensity, the brickwork becomes red-hot, when the fire is readily communicated to the timber or flooring found in close contact: it is in this way that numerous fires have occurred, and the result has been the loss of much valuable property, and in not a few instances a sacrifice of life. From long experience, I feel assured that some better and safer plan in the construction of chimneys and flues is much wanted.

"Considerable danger from fire is often occasioned from alterations, particularly in business premises, in appropriating rooms and apartments that were formerly used for domestic purposes into store-rooms: in some cases it is decided to line the walls with boards, to which shelves may be attached; and, in order that the frame-work may be secure, carpenters will drive wedges of wood into the cross joints of the brickwork, and the ends of these wedges will sometimes find their way into the flues; and should this be the case where there is a lodgment on which there is an accumulation of soot, a spark may at any time ignite it, and fire by this means be communicated to the wedge, and from thence to the lining boards, and from thence to the shelves, till the room and premises become a prey to the flames. In several cases I have been called in to examine flues, where an escape of smoke has been perceived, and I have found that it has been generally produced from wedges being driven into the brickwork in close connection with the flues, and in some cases at an angle, with the end of the wedge projecting into an accumulation of soot, when, should the soot have ignited in this case, or the chimney have taken fire, but little hope could have been entertained of the safety of the building.

"In order that the community at large may be rendered safe, and their property secure, chimneys and flues in all buildings erected in future should be formed without angles, slants, or lodgments of any kind. This does not imply that chimneys should be made perfectly upright: flues may deviate a distance of 10 or 15 feet, if required; but instead of slants and angles, well-regulated curves should be adopted, allowing the machine to pass freely to the top, when the soot in this case would all be brought down into the fire-place, and masses of smouldering soot, under these circumstances, could never again occur."

We fully agree with Mr. Glass as to the necessity for greater care in the construction of flues and chimneys than is often exhibited.—*Builder.*

(18.) *Preservation of Stone.*—A correspondent of the "Building News" says—"Reading the interesting correspondence in your Journal on the Preservation of Stone, I find one process in which chloride of sodium or common salt is said to be found in the pores of the stone. Allow me to inform your readers, for years I have used in cleaning down old stone with a very hard face a solution of common salt as the best assistant to the rubber or drag for removing the face. The softening character thus exhibited by the salt would naturally suggest its very damaging effect as constituting a part of any processes in connexion with the preservation of stone from decay.—I am, &c.,

"A MASON."

(19.) *Thickness of Retaining Walls.*—The following table is given in "Mathematics for Practical Men:"—

Nature of Earth.	Thickness of wall, its height being 1.		
	Wall of brick 109 lb. per. cubic foot.	Wall of unhewn stone, 135 lb. per cubic foot.	Wall of hewn freestone.
Vegetable earth, carefully laid course by course................	·16	·15	·13
Clay, well rammed...	·17	·16	·14
Earth mixed with large gravel.........	·19	·17	·16
Sand.....................	·33	·30	·26

(20.) *Strength of Stone to Resist Crushing.*—Mr. Fairbairn, in his "Useful Information for Engineers," gives the following table:—

Porphyry, ...	40,416
Grauwacke, Penmaenmawr	16,893
Granite, mean of three	11,565
Sandstone, Yorkshire	6,127
Ditto, mean of 9 experiments	9,824
Ditto, Runcorn	2,185
Limestone, ...	8,525
Ditto, Anglesea	7,579
Ditto, Magnesian—mean	5,074
Brick, hard	1,888
Ditto, red	805
Ditto, mean of 4 experiments	1,424

The experiments detailed by Mr. Fairbairn show, that as a rule "the crushing weights are as the areas of the surface subjected to pressure. As is well known, great advantage was found in bedding stone in its natural position, the difference being as 10 : 8 in favour of the stone being crushed upon its bed to the same when crushed in the line of cleavage; and the same may be said of the limestones. A list of the bearing powers of various materials employed in building is given, the data being obtained from experiments instituted by Mr. Latimer Clarke, during the construction of the Britannia and

Conway tubular bridges; the average weight supported by brickwork set in cement, the average weight of 9-inch cubes being 53 lbs., was 33·5 tons per square foot, being equal to a column 583·69 feet high of such brickwork. Sandstone, of an average weight of 130 lbs. 10 oz. per cubic foot, or 17 feet per ton, crushed at an average weight of 134 tons per square foot, equal to a column 2,351 feet high of the material; while limestone, equal to 165 lbs. 5 oz. per cubic foot, or 13½ feet per ton, crushed at an average weight of 471·15 tons per square foot, equal to a column 6,433 feet high of such material."

(21.) *Mortar and Hydraulic Limes.*—From a capital leading article in the "Builder" on "Modern Mortar and Modern Masonry," we take the following most suggestive sentence or two:—"Hydraulic limes and cements must be preserved dry: they should be used fresh, and at the first tempering. The sand should be sharp, angular in its quartz-grains, and clean: one, by measure, of ground-lime to one and a half of sand and half of furnace ashes, properly incorporated on a clean floor and ground in a mortar-pan,—then used new and hot liberally, will make good work. For brickwork the bricks should be previously wetted by immersion; for rubble masonry, the stones should be free from loam or dirt; and grout, made from the mortar, diluted to a pouring consistency, should be so used as to wet the whole wall and fill every interstice. This is the great secret for producing enduring masonry: good mortar, cleanly made, used fresh, with wet bricks, and with abundance of grout in rubble-work, and in walls of brick where more than a brick and a half in thickness is set. Mortar should never be stinted, neither in beds nor in joints, but full and outflushing quantities should be insisted upon. Thin beds of mortar and half-filled joints never produce work so strong and enduring as where the beds are thicker and fuller. Some of the oldest rubble masonry and brickwork are one-third or one-fourth mortar. And these are about the proportions of some of our best modern rubble masonry and brickwork."

(22.) *Thickness of Walls.*—From Mr. Molesworth's valuable "Pocket Book of Engineering Formulæ," (Spon and Co., London,) we take the following table:—

Building of Outer Walls.	Maximum height of Wall.	Width of Footings.	Minimum Thickness of Walls in inches.						
			Ground Floor.	First Floor.	Second Floor.	Third Floor.	Fourth Floor.	Fifth Floor.	Sixth Floor
1st class dwelling.	85 feet.	38½ in.	21½	21½	17½	17½	17½	13	13
2d do.	70 ,,	30½ ,,	17½	17½	17½	13	13	13	—
3d do.	52 ,,	30½ ,,	17½	13	13	13	13	—	—
4th do.	38 ,,	21½ ,,	13	13	13	8½	—	—	—

SECTION FOURTH.—TERMS USED IN CARPENTRY AND JOINERY.

Abutting Joint.—(See *Joints.*)

Angle Bar.—The bar, as *a*, fig. 29, placed at the corner of a projecting window.

Angle Bead, sometimes also called *Angle Staff.*—Strips of wood placed at the angles of projecting parts—as chimney-breast corners—to protect plastering. Fig. 30 illustrates an angle bead *c*, secured to the wood brick *b*, or guards *d*, fixed in the walls.

Fig. 29.

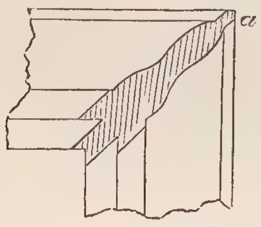
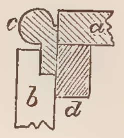
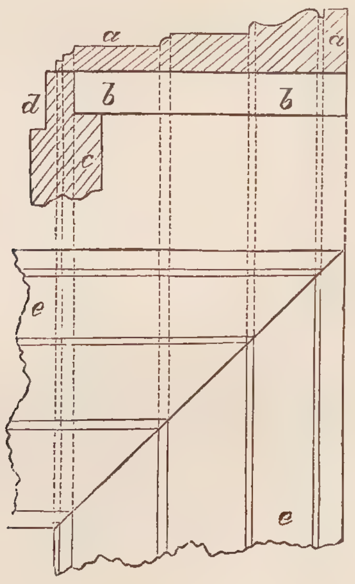


Fig. 30.



Architrave.—The assemblage of mouldings fixed round the sides and top—technically called the *margin*—of a door or window opening. Fig. 31 shows the section and elevation of "architrave" for a door casing;

Fig. 31.



a a the architrave fixed to the "grounds' *b b* *c e* the "door jamb," with "rebate" *d*; *e c* is the elevation.

Arris.—The angle-edge *a*, fig. 32, formed by the meeting of two posts placed at an angle to each other; by cutting off the angle, as in the line *b c*, the "arris" is said to be "taken off."

Fig. 32.

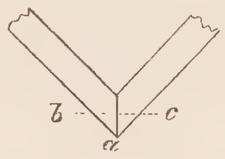
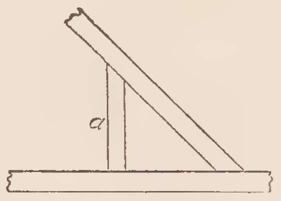


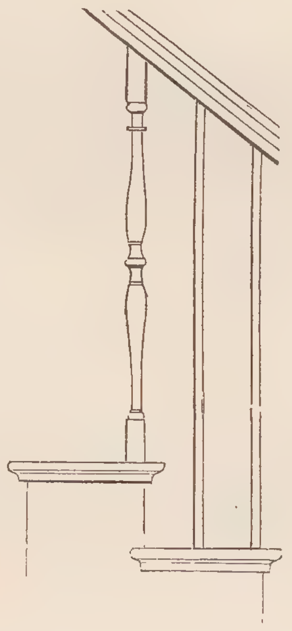
Fig. 33.



Ashlets.—The vertical studs, as *a*, fig. 33, placed at the sides of an attic room formed in the roof.

Balusters.—Vertical bars, either square or turned, as in fig. 34, fixed to the steps of a stair at lower, and to the hand-rail at upper end.

Fig. 34.



Bead.—The rounded moulding made on the edge of staff, as *a*, fig. 65, Plate D. When the bead is flush with the upper surface, as in fig. 66, it is called a "*quirk bead;*" fig. 67 is a "*double quirk bead.*" When raised from the surface it is called a "*cock bead,*" as in fig. 68, Plate D.

Bead-butt, in panelling, when the bead *d* is worked or formed upon the edges *a b* of the panel, and butts against the rail or style *a a*, *b b*; in this case the bead or moulding is carried up the sides only of the panel. See fig. 35.

Fig. 35.

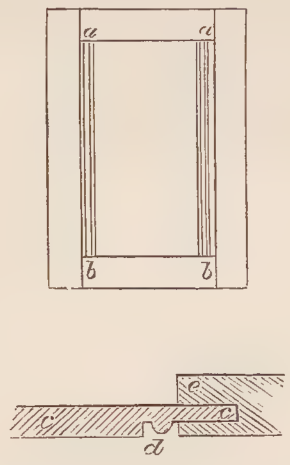
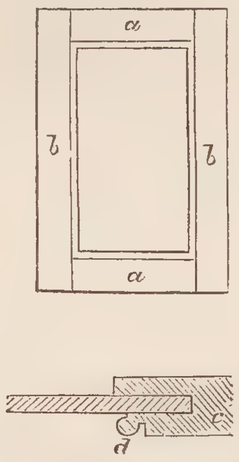


Fig. 36.



Bead-flush is when the bead *d* is formed on the rail or style *c* all round, so that the moulding encircles the panel on its four sides, as *a a*, *b b*. See fig. 36.

Beam.—Timber placed horizontally to resist a pressure or carry a weight, the ends *a b*, fig. 37, resting upon the wall. Fig. 38 illustrates

Fig. 37.

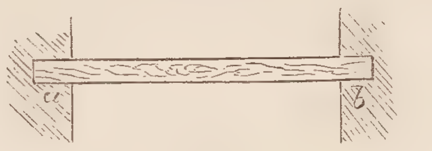
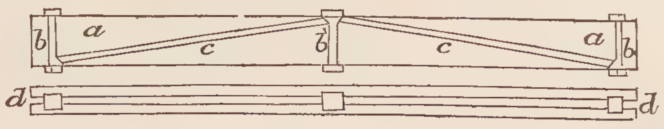


Fig. 38.



a trussed beam, *a a* being one of the flitches or sides of the beam; *b b* the butting parts of iron, against which the struts *c c* butt; *d d* is the plan showing the two flitches.

Bearing of a Beam is the distance in the clear between the line of walls *a b*, fig. 37.

Binding Joists.—(See *Floor.*)

Binding Rafters, otherwise called *Purlins.*—(See *Roof.*)

Bird's Mouth.—The part cut out at the foot *b* of a piece of timber to abut or rest upon the exterior angle *a* of another piece, as shown in fig. 39.

Fig. 39.

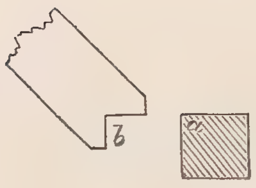
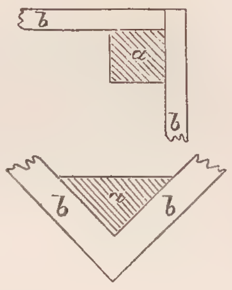


Fig. 40.



Blocking.—A piece of wood *a* glued or nailed in the interior angle of two pieces *b b*, in order to strengthen them. See fig. 40.

Bolection Moulding.—Any projecting moulding, as fig. 69, Plate D.

Bond Timbers.—Timbers built into walls to strengthen them, acting as ties.

Bottom Rail.—(See *Door.*)

Boxings of a *Shutter*, which see.

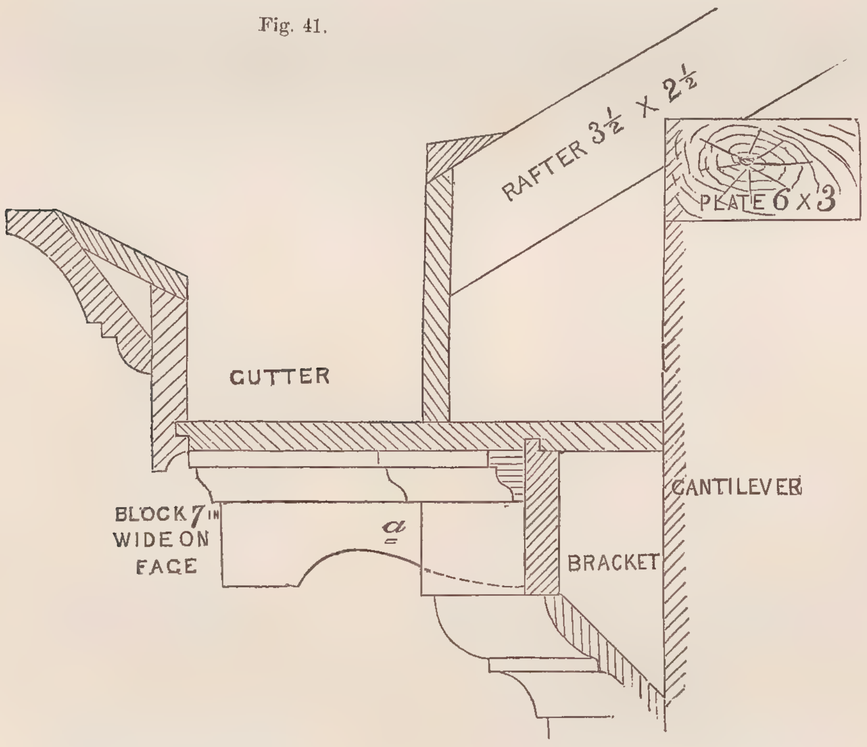
Brace.—(See *Roof.*)

Bracketing.—(See *Cornices.*)

Bressummer.—A beam, as in fig. 37, stretched across a void or opening in a wall to carry a weight, and resting on the wall at the ends *a b*.

Bridged Gutters.—Gutters, in which the gutter-boards are supported by bearers, as *a*, fig. 41. (See *Gutters.*)

Fig. 41.



Built Beam.—(See *Framing.*)

Cantalivers.—Pieces of timber, as *a*, fig. 41, projecting from the wall at intervals thereon, and used to support the eaves or gutters.

Carriage of a Stair.—The timber which carries the steps. (See *a a*, fig. 70, Plate D.)

Casting.—The twisting or winding of a piece of wood is so called, which is caused either by unequal exposure to the weather or unequal strain.

Fig. 42.

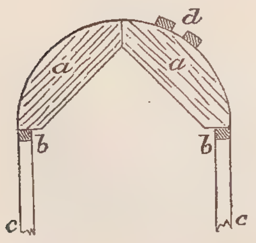
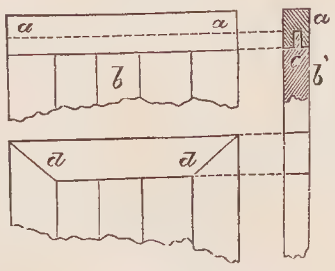


Fig. 43.



Centring.—The arrangement of timbers to support an arch while building. Fig. 42 illustrates a simple form of centring for window or door arches. The side pieces *a a* are supported on wedges *b b* on the top of the uprights *c c*; *d d* the bolster pieces.

Chamfering.—Cutting off the right angles or edge of a piece of stuff at a slope or level.

Clamp.—A piece of wood *a a* fixed to the end of boards *b*, so that the fibres of one are placed transversely to the other, and the object of which is to prevent the boards from casting. The end piece is called the "clamp," as in fig. 43.

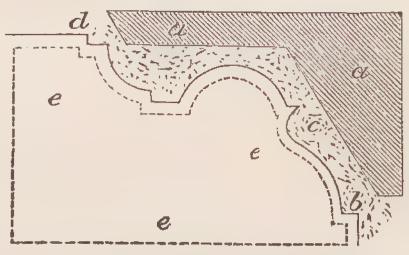
Clinching.—Bending back the ends of nails which show on the reverse side of wood through which they are driven.

Cocking.—The notching of a beam on to a wall-plate is so called.

Collar Beams.—Pieces of timber framed horizontal between the heads of queen posts.—(See *Roof.*)

Cornices (*Bracketing for*).—Wooden brackets fixed to plugs in the wall, forming a core for the lath and plaster, and partaking to a certain extent of the contour of the same. See fig. 44, where *a a* is the bracket, *b b c* the plaster cornice, the outline for which is made by the board *e e*.

Fig 44.



Couples.—Rafters framed together in pairs, with a collar or tie to prevent the spreading of the feet of ditto; thus each pair forms a truss.

Cradling.—Centering for culverts.

Curtail Step.—The lowest step of a stair, formed in a spiral line, as in fig. 71, Plate D; it is turned towards the well-hole.

Dog-legged Stairs.—Stairs which have no open well-hole, as in fig. 72, *a*, Plate D.

Doors.—Fig. 45 illustrates the parts constituting a door—*c* "bottom rail," *d* "middle or lock rail," *e* "top rail," *a a*, *b b*, the "styles," *b b* is the "hanging style," being that to which the door is hinged to the frame; the part *f g* is called the "muntin." Doors are of various kinds, as a "ledged," *b b* the "ledges" in fig. 46; "ledged and braced," *b b* the "ledges," *c c* the "braces," as in fig. 47; "4-panel," as in fig. 48; "6-panel," as in fig. 49. A "casement door" is that in which the upper part is composed of a glazed part, to give light to an inner apartment or lobby.

Fig. 45.

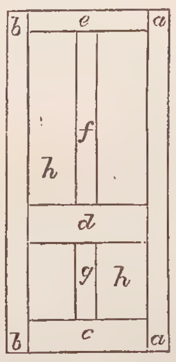


Fig. 46.

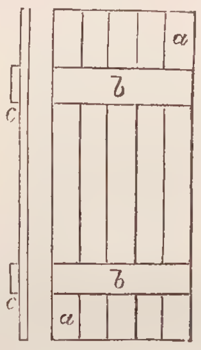


Fig. 47.

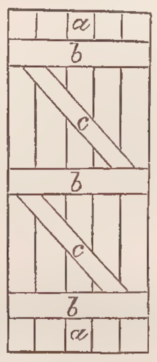


Fig. 48.

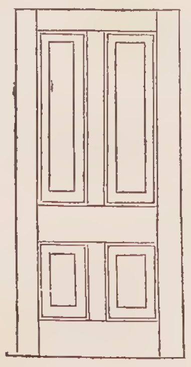
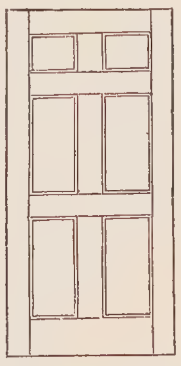


Fig. 49.



Dormer Window.—The window placed in the sloping side of the roof to light an attic apartment; the part *a a*, fig. 50, is vertical; in this the window frame is placed, the ridge *b* projecting horizontally; the sides *c c* are sloping like a roof, and are covered with slates.

Double-hung Sashes.—Windows in which the upper as well as the lower sash is hung with lines and weights.

Fig. 50.

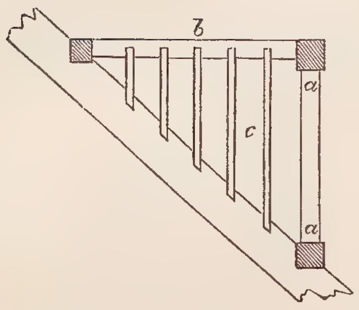
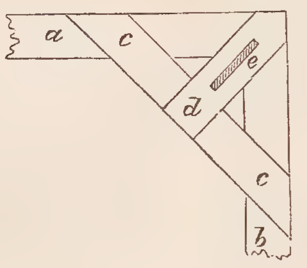


Fig. 51.



Dragon Piece.—The piece of timber *d d* which supports the foot *e* of a "hip rafter" (see *Roof*); *c c* is called the "angle tie;" *a b* are the "wall plates." See fig. 51.

Elbows of a Window.—The side panels placed under the shutter of a window. See fig. 52.

Fig. 52.

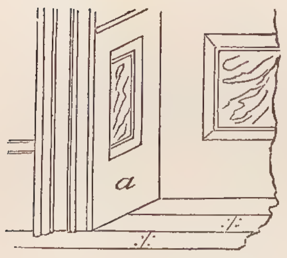
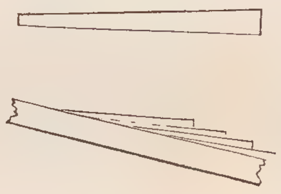


Fig. 53.



Feather-edged Boards.—Boards thicker on one side than the other are so called, fig. 53. They are used to cover the sides or roof of wooden sheds, as shown in the lower part of fig. 53.

Framing.—A *Frame* in carpentry is applied to any combination of beams (fig.72, Plate D) firmly fixed together. A *Strut* is a piece in any framework which resists a *compressing* force. If the pieces E D E D in the frame A B B D, fig. 72, Plate D, are intended to resist a compression in the direction B B, they are *struts*. A *Tie*, in framework, is a piece intended to resist a force of *extension*. If the pieces E D E D are made to resist an extension upwards, or from A A to B B, they are *ties*. A *Brace*, in like manner, is a piece resisting a tendency to *flexure*. If E D E D are built with the view of resisting a tendency to bend in the beam B B either outwards or inwards, they are *braces*. A *Beam*, in house carpentry, is the largest or principal piece in a building, lying across the walls or supporting the rafters. A *Built Beam* is either several beams or thicknesses of beams *united* together, figs. 73, 74, 76, Plate D, or two or more beams *connected* together, fig. 75, Plate D, by upright and diagonal pieces. A upper beam, B lower beam, *a a* uprights, *b c* diagonal braces. A course, in a *built* beam, is the name given to each piece or beam so united together. Figs. 73, 74, 76, Plate D, are built beams of *three* courses each. *Indented Courses* of a built beam, fig. 74, are courses of which the beams or posts are fitted to each other by indents to prevent them from slipping. *Notched Courses in a Built Beam*, fig. 76, are such as have rectangular notches cut into the top and bottom of each, these notches being arranged to lie opposite to each other, in order that a block of hard wood called a *key*, *b b*, may be fitted into them to prevent them from slipping. A *Curved Frame*, or *wooden arch*, fig. 77, is either a curved-built beam of several courses abutting end to end, or of two curved-built beams parallel to each other, with an interval between them connected by upright and diagonal pieces *a a*. The *Span* of a curved frame is the horizontal distance between the two extremities M M of the arch. *The Rise* in a curved frame is the vertical distance A B from the line M M to the crown B of the arch.

Flooring.—The timbers used in flooring are illustrated in fig. 78, Plate D. *Girder*, A A, is the large piece of timber in the middle of the breadth of a floor which gives support to all the others. *Binding Joists*, B B, are pieces which are supported by the wall and by the *girder*, and run transverse to the latter, to which it is secured by a *mortise* joint. *Ceiling Joists*, C C, are pieces fixed near the lower edges of the *binding joists* and supported by them, running parallel to the *girder*. *Wall Plates*, D D, are pieces of timber that appear on the walls and which support the *binding joists*. *Bridging Joists*, E E, are pieces of timber placed over the binding joists, and run parallel to the girder. This kind of flooring is called "double flooring"—single flooring is used for small spans, and consists of simple joisting placed parallel to one another like E E, and above which are placed the flooring planks.

Girder.—(See *Flooring.*)

Grounds.—Pieces of wood *b* fixed in a wall *a* to which the exterior finishings of a room are nailed, as the skirting *d* shown in fig. 54. The surfaces of grounds are flush with the plaster; and the upper edge *b* is provided with a groove in which the plaster *c* keys.

Gutters are of various kinds; one is shown in the diagram annexed (fig. 55), as fixed over a window projecting from the ground floor. *a* the sill of window in second floor; *b b* bracket; *c* cornice connecting the gutter; *d d* enrichment; *e e* bressummer; *f f* wall. In fig. 41 we give the drawing of a bridged gutter at the eaves of a roof.

Fig. 54.

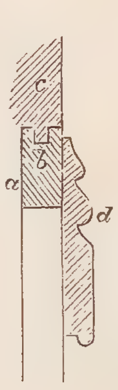
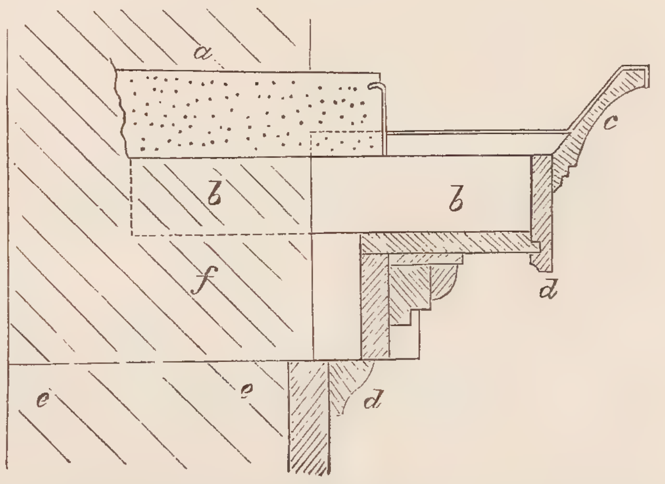


Fig. 55.

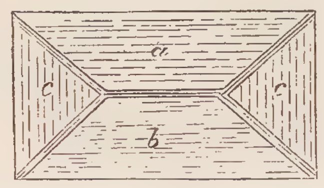


Hanging Style.—(See *Door.*)

Hinging.—The hanging of doors to the hanging style. The forms of hinges are various; one is illustrated in fig. 79, Plate D.

Hip Roof.—A roof in which the ends *c c* are at the same angle or inclination, as the sides *a b*, fig. 56.

Fig. 56.



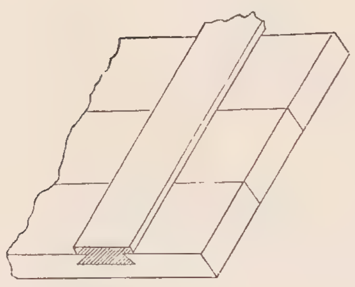
Jambs.—The vertical sills, *b b*, fig. 18, of an opening in wall, as *a a*. The lining of a jamb is called the "jamb lining," and this is fixed to a vertical post fixed in the wall, called a "jamb-post."

Joints.—*A Fish*, (*Fr. af-fiche*, from *L. ad-fixus*, a joining or fixing to,) is used only for rough work. The pieces *a b*, fig. 80, Plate D, *abut* end to end, and are confined by two pieces above and below, *c d*, and sometimes also by two side pieces if exposed to a lateral strain, bolted on two or four of the sides as the case may be. This process is termed *fishing a beam*, and a beam so joined is called a *fished beam*. Fig. 81 is a fish indented on the upper side. *A Scarf*, or *Scarph Joint*, (from Sp. *escarpa* or *scarp*, a sloping or inclined cutting,) is employed where the beam requires to be of the same thickness throughout, and is a joining made by *cutting* the surfaces of the two beams parallel one to the other, and generally with a slope, as in figs. 82 and 83. The mode of cutting is varied according to the direction and nature of the strain to be resisted. A beam so joined is called a *scarfed beam*. *A Dovetail Joint*, fig. 84, (so called from its shape,) is a variety of the *Mortise* and *Tenon*, fig. 85, Plate D, used for connecting two beams, one lying horizontally and the other perpendicular, where the end of the horizontal beam *rests* upon the perpendicular one, and the tenon is let into the mortise from one of the sides. The *Mortise and Tenon Joint.*—Mortise, a sinking or letting down, remotely from *Mors*, death, as in a secondary use of the word extensively employed in the languages of Southern Europe, where a debt is said to be mortised, (*amortisado*,) sunk, brought down, or made to disappear by means of partial payments. Tenon, holding together, from Fr. *tenir*, to hold.—This joint is used to connect two beams, A B, fig. 85, where the end of one rests upon the other either perpendicularly or obliquely. *a* the tenon; *b* the mortise; *c* the hole for a wooden pin driven through the sides of both. Fig. 86 is the form of a mortise joint for oblique or inclined pieces, *a b c* notch or mortise in the piece B to receive the end of A, *a b d* form of the tenon. This joint may be secured either by a wooden pin, or iron screw bolt. Fig. 87, Plate D, illustrates a method of joining timbers at the corner, as two wall plates. Fig. 88, the method of joining a tie beam to a wall plate. The above are all joints used in carpentry. Figs. 89 to 92 illustrate the joints used in joinery—89 is the "dovetail" joint, 90 a "mitre" joint, 90*a*, 90*b*, 91, and 92 are other forms of joints.

Joists.—(See *Flooring.*)

Key; in joinery a piece of wood let into, and running transversely across other pieces to prevent them from twisting or warping, see fig. 57.

Fig. 57.



King Post.—(See *Roof.*)

Landing, that part of a staircase on the level of the floor to which it leads.

Lengthening Timbers, also called scarfing; for which see *Joints.*

Lever or Luffer Boards, a set of boards set parallel to one another in a framing, but at an angle, in order to allow air to pass through between them, but to prevent the passage of rain. Fig. 58 shows this kind of boarding in elevation and section.

Fig. 58.

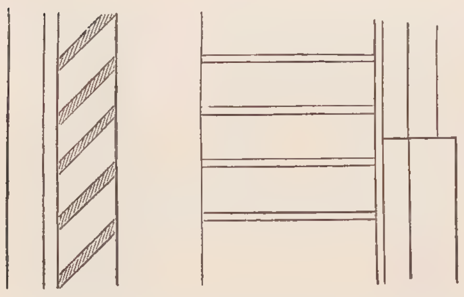
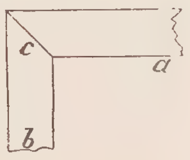


Fig. 59.



Lintel, a short beam placed over an opening, (see fig. 38,) on which the inside wall is carried.

Margins of a door, otherwise called margents, the flat part of the styles or rails.

Middle Rail, also called the "lock rail," see *Door.*

Mitre; when two pieces of wood placed at an angle to each other are joined, so that at their vertex they form an angle double that of other piece, they are said to be mitred, fig. 59, and the joint is called a mitre joint; see also fig. 90, Plate D.

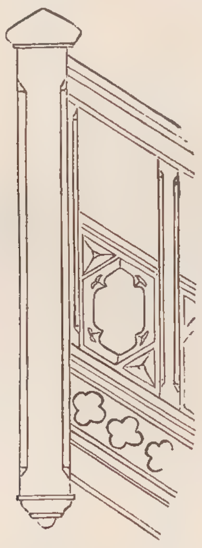
Mitred Borders; the boarding or frame placed round hearthstones.

Mortise.—(See *Joints.*)

Mullion, also called a "munnion"—the vertical bar in a window which separates the two casements from each other.

Newel (in staircasing).—The post at which the winders (on a dog-leg stair) terminate; the turned post placed at the bottom of a stair is also so called, see fig. 60.

Fig. 60.



Notch Board.—The board into which the ends of the steps of a stair are fixed, this board being secured to the wall. In fig. 61, *c c* is the notch board; *b b* the vertical cuttings into which the ends of the "treads" (which see), *a a* those into which the ends of the "risers" (which see) are housed.

Open Newelled Stairs are those divided into two or three flights, and have a rectangular well hole.

Panels.—The thin boards fitted into the vacant spaces between the styles or rails of framing (see *Door*). In fig. 62, *a* is the rail or style; *b* the panel; *c* the moulding worked round the edge of the framing (see *Bead Flush*). In place of the panel being of the same thickness throughout as at *b*, it is sometimes "raised"—as it is termed—that is, made thicker in the middle than at the sides, as at *d e*, fig. 62.

Fig. 61.

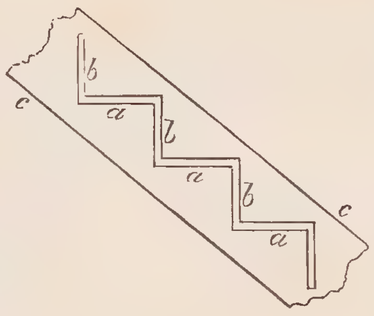
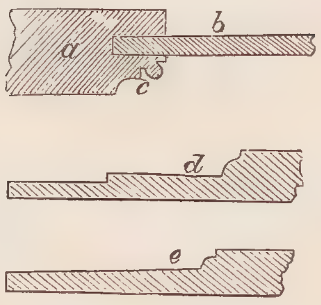
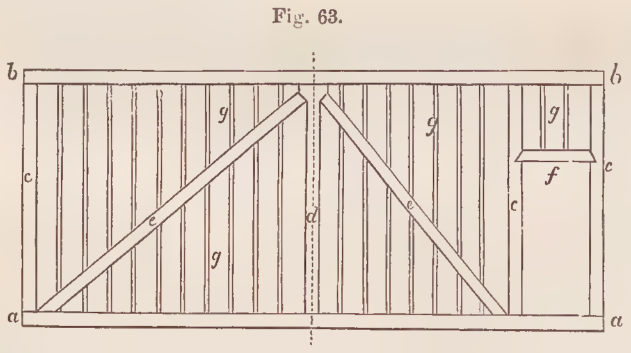


Fig. 62.



Partitions.—The timber framing which divides one apartment from another; the parts of which a partition is formed are called "quarters." In fig. 63, *a* is the "sill," *b f* "head," *e e* "braces," *d d c c* "upright posts," *g g* puncheons.

Fig. 63.



Pitch of a Roof, the angle or inclination of the sides of a roof.

Plugs, pieces of timber driven into wall to which the joiner's work is nailed.

Pole Plate.—(See *Roof.*)

Principal Rafters.—(See *Roof.*)

Purlins.—(See *Roof.*)

Quarterings, the studs of a partition.

Quirk.—(See *Bead.*)

Rafters.—(See *Roof.*)

Raking Moulding.—A moulding, the plane of which is at an angle to a horizontal line, (see fig. 64, Plate D.)

Ramp.—The curve or rise in the hand-rail of a stair, necessitated by a sudden rise of the steps, see *b*, fig. 70, Plate D.

Rebate, a rectangular piece, as *a*, fig. 64, cut out of the edge of a piece of stuff.

Return Bead, also called a "double quirk," as fig. 67, Plate D.—(See *Bead.*)

Ridge Piece.—(See *Roof.*)

Riser.—The vertical parts of a stair, as *a a*, fig. 65.

Fig. 64.

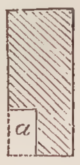
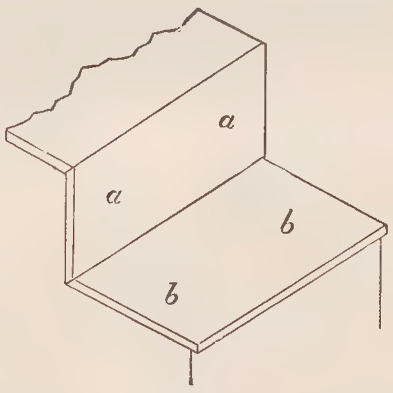


Fig. 65.



Roof.—The assemblage of timbers used to support the slating or tiling of a house, it is more properly termed a roof *truss.* The timbers used in a king-post roof are as follows:—*Wall Plates*, A. A, fig. 93, Plate D, are the pieces of timber that lie upon the tops of the walls. *Tie Beams*, B B, are the pieces of timber that extend over the area and rest upon each *wall plate. The King Post*, C, is the piece of timber which rises from the middle of the *tie beam. The Struts*, or *Braces*, D D, are the two pieces of timber that branch out from the middle of each *king post. The Principal Rafters*, E E, are the pieces that rise from each end of the *tie beam* which meet the *king post* at the top, and which are supported in the middle by the *strut. The Pole Plate*, F F, is the piece supported by the ends of the *tie beams* and overtopping each *wall plate. The Purlin*, G G, is the piece of timber on either side which is supported by the *principal rafters* at the middle, and parallel to the *wall and pole plates. The Ridge Piece*, H H, is the piece of timber which runs along the tops of the *king posts*. *Common Rafters*, I I, or spars, are the pieces on either side, supported in the middle by the *purlin*, at the bottom by the *pole plate*, and at the top by the *ridge piece*. *Roof Trusses* are of various kinds. In fig. 66 we give the elevation of one for a "lean-to roof;" this is used for minor structures, as outbuildings, and for short spans. *a b c* the "wall plates;" *d* the "tie beam;" *e* the "rafter;" *f* the "bridged gutter." In fig. 67 we give the elevation of a truss for a "collar beam roof." *a a* the wall plates; *b b* the rafter; *c* the collar. The drawing in fig. 93, Plate D, is that of a "king post" roof; that in fig. 68 annexed, is for a "queen post" roof. *a a* the "queen post;" *b* the "straining cill;" *c* the "collar beam." Fig. 69 is a "curb" or "mansard roof," used where sloping ceiled attic apartments are required in the roof formed by the beams *a b c d; e* is a door way, *f* the filling in pieces; *g g* the puncheons. Fig. 70 is a truss for a Gothic roof. *a* the hammer beam, supported by the corbel *b*. Fig. 70*a* is a flat roof. *a a* the flat lead covering supported by the joists *b*; *c c* upper beam; *e e* lower beam; *d d* struts or braces; *f f* wrought-iron truss or king rods.

Fig. 66.

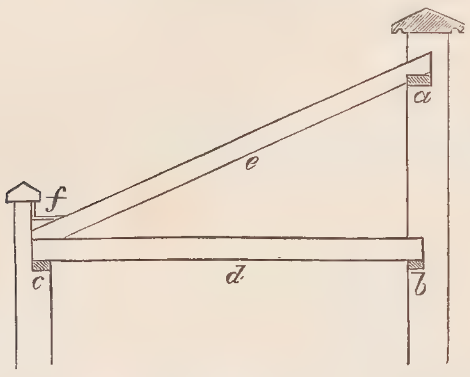


Fig. 67.

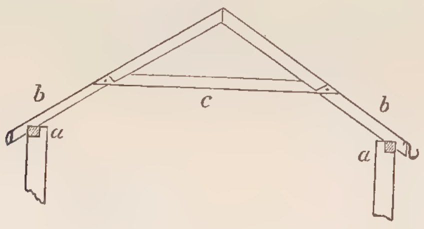


Fig. 68.

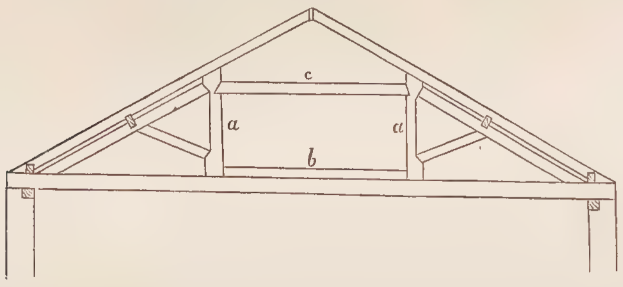


Fig. 69.

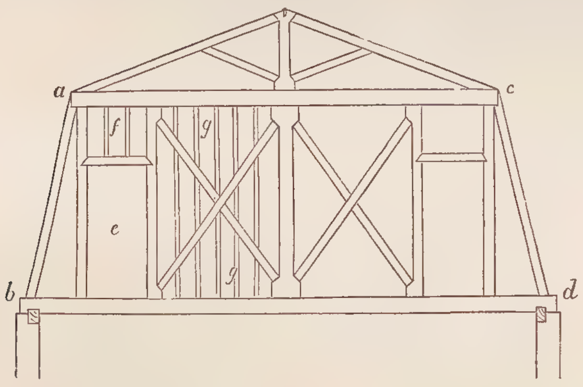


Fig. 70.

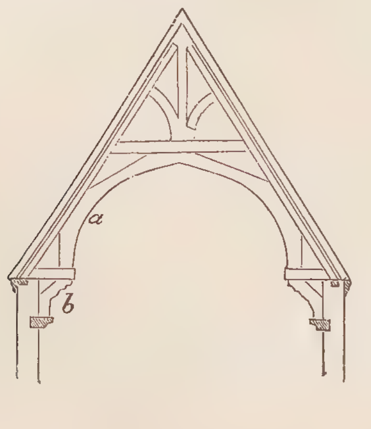
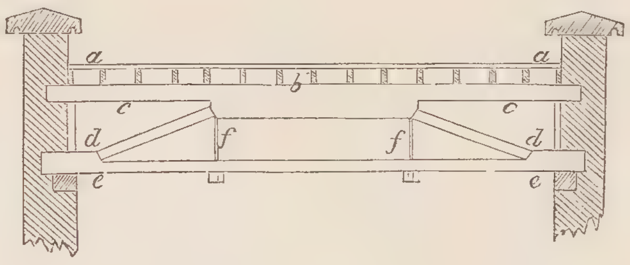


Fig. 70*a*.



Sash-frame.—The framework used to support the glass of a window. Sash-frames, when of small dimensions, are fixed to the jamb linings or framework, or are hinged at the side thereto, so as to open freely. The bars, horizontal and vertical, which support the glass, are called *sash-bars*, or astragals. Various forms of these are shown in fig. 94, Plate D. When the upper part only of a frame is suspended, or "hung," as the technical phrase is, the sash is said to be "single hung;" when both the lower and upper parts are hung,, the sash is said to be "double hung." Each sash is suspended by means of cords and weights, which pass over pulleys fixed in the frame. The side of a sash-frame is made up of four pieces, called "casing pieces." The one against which the edge of the sash slides is called the "pulley piece," or pulley style," as to this is fixed the pulley over which the cord or chain passes, attached to the sash at one end, and to the "sash-weight" at the other. The three other pieces of the "casing" are termed "linings," of which C, fig. 95, Plate D, is the "outside lining;" A the "inside lining," or that next the room, and parallel to the "outside lining" C; D is the "back lining," and B the "pulley piece;" E is the "inside bead;" the "parting bead" F, is a thin slip nailed vertically on the face of the "pulley style" B; two vertical guides are thus formed on the face of the "pulley style," one between the "outside lining" C and the "parting bead" F, the other between this and the "inside bead" E. In these guides the upper and lower sashes slide. Where shutters are used, they are jointed by a hinge *u*, fig. 95, Plate D, to the "inside lining." (See *Shutter Boxings*.) The sash weights, which counterbalance the weight of the sash, are shown at G G; they are divided by a vertical slip H, called the "parting slip." In fig. 71 we give a section of the lower part of a sash-frame; *a* part of the "stone cill;" *b b* the "oak cill;" *f* the bottom rail" of sash; *c* "inside bead," carried round both the head sill and sides; *d e* "window back lining." In fig. 72 we give the section of upper part of the same sash; *a* "sash;" *b* "top rail" of sash; *c* "inside bead;" *d* "outside bead," which is carried round the sides and head only; *e* the "head;" *f g* "soffit lining" in the inside of room.

Fig. 71.

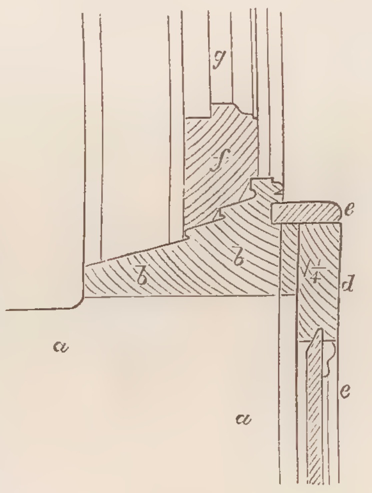
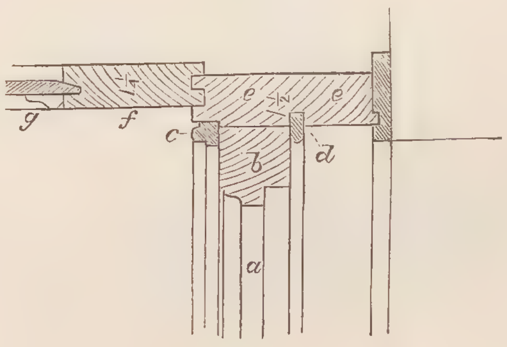


Fig. 72.



Shutter Boxings.—In fig. 95, Plate D, we give drawing of the arrangement of this; A the "inside lining" of window; I I I the "back lining" of boxing; J the "ground" to which the "architrave" *h* is fixed, forming the other end of boxing. The boxing, then, may be said to be made up of the "inside lining" A A; "back lining" I I I; and "ground" J.

Shutters.—In fig. 95, Plate D, K K, the "front shutter," is hinged by the hinge *u* to the "inside lining" A A; L and M are called the "back flaps," of which L, the "first back flap," is hinged at *v* to the "front shutter" K; the "second back flap" M to the "first back flap" L by the hinge *w*. Shutters are also made to go into vertical shutter boxes, as illustrated in fig. 73, where *a* is the "ground" and *b* is the "skirting;" *c* "floor;" *d* "joists" (a cellar under floor, *e* being ceiling of cellar); *f* "bottom rail" of sash; *g* "back lining" to shutter boxing; *h* "front lining." The shutter is not made to slide up in one piece, covering the window entirely, but is made in two halves, the half *i* covering the upper sash, *j* the lower, *k* stone sill, *n m* window base, *l* brickwork.

Fig. 73.

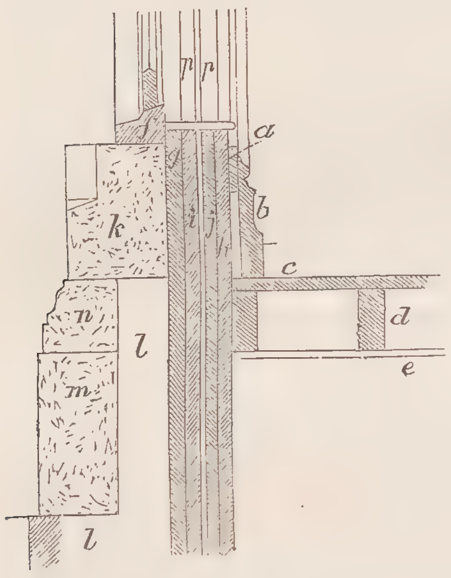
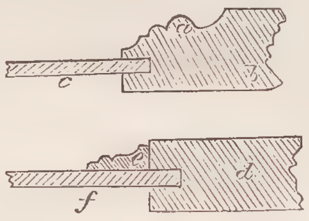


Fig. 74.



Skirting.—The moulded boards running round a room and resting on the floor, as *b*, fig. 73.

Staircase generally includes not only the well-hole, or apartment in which the stairs are placed, but the steps also. When a staircase reaches from one floor to another in a straight line it is called a "flyer;" where the direction is changed, it is called a "winder" (see fig. 72*a*, Plate D). The "bottom step" of a staircase is the first step, and is usually rounded in a scroll form, called the curtail (see *Curtail Step*), and it supports the newel (which see). The "landing" of a stair is the top step, on a level with the floor to which the stair leads. In winding staircases the space midway between the first and second flights is called the "resting place."

String-board.—The board in a staircase, placed next the well-hole, which encloses the ends of the steps.

Stuck On.—When the moulding is worked on the edge of a rail, as in fig. 74, where *b* is the rail, *a* the "stuck-on" moulding, and *c* the panel, it is said to be *stuck on;* when it is in a separate piece, and fixed to the rail or panel, it is called *laid on,* as in fig. 74, where *d* is the rail for the panel, *e* the "laid-on" moulding. Where no moulding is laid on or stuck on, the panelling is called "square framing."

Tread of a Stair.—The horizontal parts *b b*, fig. 65.

Trimming Joists.—The two "joists" *b b* into which the "trimmer" *c* is framed, fig. 75. For each joist *d* the trimmer *c* has to carry, ⅛th of an inch should be added to the thickness of the trimmer-joist.

Fig. 75.

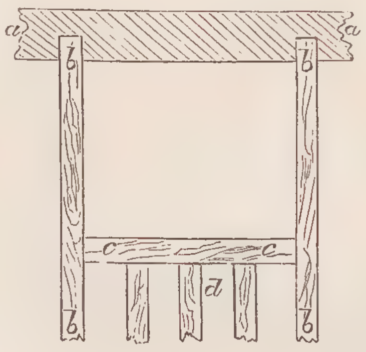
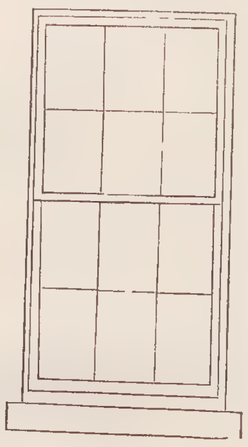


Fig. 76.



Windows.—Fig. 76 is a "sash window;" fig. 77 a "French, or casement window," the two halves of which open; they close together in the centre; Fig. 78 a "Venetian window.

Fig. 77.

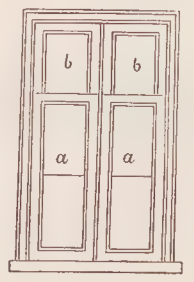
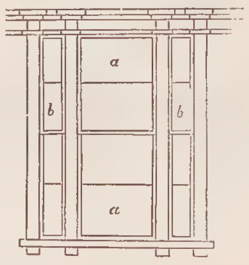


Fig. 78.



PRACTICAL NOTES AND MEMORANDA UNDER SECTION FOURTH.—CARPENTRY AND JOINERY.

(1.) A square of boarding is 100 feet surperficial. A load of timber is 50 cubic feet. A load of oak timber, however, is only 40 cubic feet. One hundred (120) of deals 12 feet long, 2½ inches thick, and 9 inches broad, make 4½ loads. The cubic contents of each plank is 1 foot 10 inches.

(2.) The following are the number of cubic feet of various kinds of timber required to make one ton:—Oak, 39; beech, 50; fir, 64; ash, 45; mahogany, 34; elm, 60.

(3.) The following are the weights of a cubic foot of various kinds of timber:—Oak, 57 lbs. 13 oz.; beech, 43 lbs. 12 oz.; fir, 34 lbs. 6 oz.; ash, 50 lbs.; elm, 37 lbs. 8 oz.; mahogany, 66 lbs. 7 oz.

(4.) *Scantling of Roofs.*—The "Inclosure Commissioners" sanction for buildings the following:—

Description of Roof.	Span.	Tie Beams.	Principal Rafters.	King Posts.	Queen Posts.	Struts.	Straining Piece.	Sill Piece.	Purlins.	Common. Rafters.	Wall Plates.	Pole Plates.
	feet.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.	in. in.
King Post,	18	7½ by 3	5 by 3	4 by 3	...	3 by 2½	...	...	6 by 3½	3½ by 2	4 by 3	4 by 4
	20	8 „ 3	5½ „ 3	4½ „ 3	...	3½ „ 2½	...	...	6½ „ 3½	3½ „ 2	4 „ 3	4 „ 4
	22	8½ „ 3½	6 „ 3	4 „ 3½	...	3½ „ 3	...	...	7 „ 3½	4 „ 2	4½ „ 3	4 „ 4
	24	9 „ 3½	6 „ 3½	4½ „ 3½	...	4 „ 3	...	...	7½ „ 3½	4 „ 2	4½ „ 3	4 „ 4
	26	9½ „ 4	6½ „ 3½	5 „ 3½	...	4½ „ 3	...	...	8 „ 4	4½ „ 2	5 „ 3	4 „ 4
	28	10 „ 4	6½ „ 4	5 „ 4	...	4½ „ 3½	...	...	8½ „ 4	4½ „ 2	5 „ 3	4 „ 4
	30	10½ „ 4½	7 „ 4	5½ „ 4	...	5 „ 3½	...	...	8½ „ 4½	5 „ 2	5 „ 3	4 „ 4
Queen Post,	30	9 „ 4	5½ „ 4	...	4½ by 4	4 „ 3	7 by 4	4 by 4	7 „ 3½	4 „ 2	5 „ 3	4 „ 4
	32	9½ „ 4	6 „ 4	...	5 „ 4	4 „ 3½	7½ „ 4	4½ „ 4	7½ „ 3½	4 „ 2½	5 „ 4	4 „ 4
	34	10 „ 4½	6½ „ 4	...	5½ „ 4	4½ „ 3½	8 „ 4	5 „ 4	8 „ 4	4½ „ 2½	5 „ 4	4 „ 4
	36	10 „ 5	6½ „ 4½	...	5½ „ 4½	5 „ 3½	8 „ 4	5 „ 4½	8 „ 4½	5 „ 2½	6 „ 4	5 „ 4

(5.) *Scantlings of Floor Joists.*—The following table is from Tredgold's work on Carpentry:—

Bearing in Feet.	Girders 10 feet apart, with 10 to 12 inch bearing on walls.		Binders 4 to 6 feet apart, 4 to 6 inches on walls.		Joists 1 foot apart.		Ceiling Joists 1 foot apart.	
	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.	Thickness.	Depth.
10	9″	7″	8	5	2½	7½	5	2½
12	10	8	9	5½	2½	8	6	2½
14	11	9	10	6	2½	9		
16	12	10	11	6½	2½	10½		
18	12	11	12	7	2½	12		
20	13	11	13	7½	3	12		
24	15	12						
28	16	13						
30	16	14						

(6.) *Remarks on Floors, Partitions, Roofs.*—From a very able paper, entitled "a Sketch of the Science of Carpentry," read by Mr. R. O. Harris before the Architectural Association, we take the following extracts:—

" *Floors.*—The assemblage of timbers used in the formation of a floor may be classed under three heads—First, single flooring; second, double flooring; and thirdly, double framed flooring. Before proceeding further, a few words as to plates. A wall-plate is a horizontal piece of timber laid on the walls of a building to receive the timbers of a floor or roof. Templates are short pieces of timber, sometimes laid under the ends of girders or other timbers, when no wall-plate is required; it should never be less than 3 feet long. Wall-plates and templates must be proportionately larger as the length and weight of the floor increases; their scantlings will in this respect vary from 4½ by 3 to 7½ by 5.

1st. *Single Flooring,*—Is formed with joists reaching from wall to wall, where they rest on the plates; in common work they are simply spiked to the plate, in better work they are notched to the plate and spiked.

The intervention of flues, &c., will frequently prevent the ends of joists resting on the wall-plate. In such cases a piece of timber called a *trimmer* is framed and secured with a wedge into the nearest joist, which is then called a trimming-joist. The other end of the trimmer frequently rests on the wall only, but it should be properly notched or secured to an iron corbel, and not go in the wall (this corbelling would also serve very well for corbelling of wall-plates, but a brick corbelling more equally distributes the bearing.) All trimmers and trimming-joists, on account of being weakened by mortices, should be half an inch thicker than the other joists. Herring-bone strutting is introduced in single floors when the bearing is over 10 feet, and when well fitted and secured, it stiffens the floor considerably. Single floors should not be used for floors beyond a bearing of 15 feet.

The following table of scantlings for joists will be found useful :—

Length, 6 feet, . .	6 by 2	Length, 14 feet, . .	2½ by 9
„ 8 „ . .	2½ „ 7	„ 18 „ . .	2½ „ 12
„ 10 „ . .	2½ „ 7½	„ 20 „ . .	3 „ 12
„ 12 „ . .	2½ „ 8		

2d. *A Double Floor.*—This floor is formed of three bearing timbers, a binding joist (which is in reality a girder); a bridging joist notched to the binder, and a ceiling joist also notched to the binder. (The manner of notching was shown in a sketch.) There are two or three ways of notching the ceiling joists. They are plainly notched and spiked to the under side of the binder, or they are notched to a fillet nailed on the binder, and they may be what is called "pulley mortised" into them, that is, there is a chase cut in the binder long enough to allow of the tenons of the ceiling joists being obliquely introduced into them and driven up to their places.

The scantling for timbers of this kind of floor will be the same as given for double framed flooring, of which it is a species.

Double Framed Flooring.—In double framed flooring the binders, instead of resting on the walls, are generally framed into girders reaching from wall to wall. Bridging joists are the same as described for single flooring.

In a single joisted floor, the whole weight of the floor being equally distributed along the whole line of the wall, it certainly has the advantage of a girder framed floor, where the weight is transmitted by the girder on a portion of the wall only, and it is also usually considered that a single joisted floor is, in proportion to the cubical quantity of wood it contains, stronger than a framed floor. But, as Tredgold observes, when the bearings of the joists become considerable, the ceilings of the single joisted floors are liable to be affected by the natural movements of the timber, and at all times it is easier to execute the works required to prevent the transmission of sound in a framed than in a single joisted floor.

Practically, the limit for the bearings of a single joisted floor seems to be fixed at from 20 to 24 feet; for although it is possible to obtain timbers deep enough to carry the loads of floors of larger spans, yet the depth becomes so considerable as to render the use of framed floors preferable, even without reference to the danger and inconvenience from the shrinking and warping of the joists.

A span of more than 24 feet can rarely be accomplished with ordinary timber girders, and it therefore becomes necessary to resort to the use of trussed, cast-iron, or wrought-iron girders. Of these the wrought-iron girder, from its lightness and elasticity, is very much used.

Partitions.—The framework of timber used for dividing the internal parts of a house into rooms is called a partition, or quartered partition, so named from the use of small timbers called quarterings; and when having a solid basis throughout its whole length, it requires little skill in the formation, and is generally constructed of quartering which rarely exceeds 4½ inches by 3 inches, unless required for very large partitions. A piece of timber is fixed upon the wall, which is denominated a cill, and a corresponding piece above, called a head, into which the ends of the quartering are framed; occasionally an oblique timber is inserted in the form of a strut, which gives additional strength to the partition. When the partition is to be lathed and plastered only, the door and end posts for an ordinary dwelling-house are generally made 4 inches by 3 inches, the heads and cills the same, the filling-in timbers being 4 inches by 2 inches, and about 1 foot apart. When the partition is to be what is termed brick-nogged, that is, the interspaces of timbers filled in with brickwork, the thickness of the partition will require to be half-brick thick, and the interspaces of timbers arranged so as to take two or three bricks.

When a partition has to be formed where it is not desirable to support it from below, it must not be allowed to give any of its weight to the floor, but assist in supporting and carrying the floor above if required. To do this the partition is formed into a truss, the ends of which are supported upon the main walls of the building.

The principal objects to be remembered in the construction of framed partitions, are to throw the whole weight of the partition and what it has to carry upon some principal wall or part of the building. The simplest form of accomplishing this is where the head and cill is secured with iron straps to the angle posts, a king post is framed in the centre to receive the ends of the braces, the bottom ends being well secured to the cill, the quartering is then filled in, and materially tends to stiffen the framing.

The use of iron rods with king and queen heads is much used now, and has the same advantage here as in the roof of screwing the joints of trusses firmly into their position. With these few remarks, which are necessarily incomplete, I will pass on to the next division, which is roofs, where I will more particularly describe the several ways of connecting the ends of timbers together.

Roofs.—There is nothing in the whole system of carpentry requiring more careful consideration than the construction of the roof, for upon its proper formation depends the stability of the building and safety of those for whose shelter it is designed. The first thing I will call your attention to will be 'the pitch' required, and that most consistent with the covering employed and the vicissitudes of this climate. It should never be hidden from view like an unworthy object not fit to be looked upon, nor ornamented with useless decoration that cannot be seen. A very lively writer of the day observes :—'It seems, therefore, a gross violation of the principles of taste in architecture to take away or hide the roof of a house; and it must be ascribed to that rage for novelty which is so powerful in the minds of the rich. Our ancestors seemed to be of a very different opinion, and turned their attention to the ornamenting of their roofs as much as any other part of the building. They showed them in the most conspicuous manner, running them up to a great height, broke them into a thousand fanciful shapes, and stuck them full of highly-dressed windows. We laugh at this, and call it Gothic and clumsy; and our great architects conceal the roof altogether by parapets, balustrades, and other contrivances. Our forefathers certainly did offend against the maxims of true taste when they enriched a part of a house with marks of elegant habitation which every spectator must know to be a cumbersome garret; but their successors no less offend who take off the cover of the house altogether, and make it impossible to know whether it is not a mere screen or colonnade we are looking at.' He further says :—'A house without a visible roof is like a man abroad without his hat; and we may add that the whim of concealing the chimneys, once so fashionable, changes a house to a barn or store-house. A house should not be a copy of anything. It has a title to be an original; and a screen-like house and a pillar-like candlestick are alike solecisms of taste.' Referring, again, to the inclination of a roof, I will here mention the angle of inclination with the horizon adopted in different countries :—In Greece it was from 12° to 16°; in Rome usually 23° or 24°. In England high-pitched Gothic roofs are seldom more than 6°, or equilateral; a very good inclination, and one very commonly used, is to make the height of the roof two-thirds the span. A high-pitched roof will undoubtedly shoot off the rains and snows better than one of a lower pitch. The wind will not so easily blow the rain in between the slates, nor will it have so much power to strip them off. Taking roofs generally, we may divide them into three kinds—1. The gable-ended roof; 2. The truncated roof; 3. The curb or Mansard roof. Each of these may have their ends cut off. If the same inclination as their sides, which, in a square building, would form a pyramid, in an oblong roof, the angle formed at the top is called the ridge, and that formed by the meeting of the sides the hips.

When the span of the roof exceeds 20 feet it should be formed of trusses, quite independent of the rafters. The simplest form of truss is that with a single king-post, tie-beam, a pair of principal rafters, a pair of struts, purlins, common rafters, &c.

The next form of roof I will draw your attention to is the curb-roof—that invented by Mansard, sometimes called the Mansard roof, after the name of its inventor—essentially a French roof, and a very good one it is. When sleeping apartments are required in the roof it certainly affords more space than any other form; its construction in every way meets the requirements of science. It forms ample means by its dormer-windows, &c., for appropriate decoration, and well contrived to bear the vicissitudes of this climate, and deserves to be more generally used.

It is formed of two pair of inclined planes, not unsimilar to four sides of a regular octagon. The upper rafters are called curb rafters, and a plate receives their ends, and is called the curb-plate. When the bearing of the top inclines are long, they may be formed into a king-post truss, the space between the two ties being the height of the story, and in large roofs would form the partition dividing the rooms. And the system of trussing explained, described for partitions, can be well practised in this form of roof."—*Extracted from a contemporary professional Journal.*

(6.) *Sap in Timber.*—"The sap which circulates in the tree and promotes its life is composed in its main portion of oxygen, hydrogen, carbon, nitrogen, and sulphur. The same forms a considerable body in the green or fresh wood: it changes more or less in the quality of the wood, and the intimate study of its influence is of great technical importance. It has been said that the sap flows out of a tree after it is cut down. From experiments which have been made it resulted in this being the case with very few woods, and not with the majority: with most of them the moisture evaporates.

"The quantity of sap changes very considerably during the season of the year. In elucidation of this a fine example is furnished to us by M. Duhamel de Monceau, and described in his work, 'Exploitation des Bois.' During the years 1732 and 1733 he felled each month eight oaks of equal age, and from the same spot. These were cut immediately into twenty-five pieces, each 3 feet long and 3 inches square (Paris measure), and he obtained the following results:—

340·718	pounds (Paris weight) in	December.
340·906	„ „	January.
328·031	„ „	February.
331·087	„ „	March.
311·875	„ „	April.
319·500	„ „	May.
297·312	„ „	June.
297·250	„ „	July.
314·469	„ „	August.
306·875	„ „	September.
328·906	„ „	October.
331·000	„ „	November.

(One pound Paris weight—1·0769 avoirdupois.)

"From these figures it appears that, during the months of December and January, the trees contain more sap than at any other period. It diminishes in October, November, February, and March; next in April, May, August, and September; and its quantity is least during the months of June and July.

"From another experiment, made in 1737-38 with six stems of young oaks, it was ascertained that the lower portion of the trunk weighed (hydrostatically determined) of the December wood, 1·132; April wood, 1·016; July wood, 1·017.

"This proves that there was most sap in the December wood. The difference between the April and July woods remains doubtful. The same pieces of wood were also weighed when dry, and, compared with the fresh weight, it gave the following result in lb. weight:—

	Green.	Dry.	Loss of Sap.
April wood....................	57·339	41·839	15·500
July wood	94·851	68·226	26·625
December wood	77·062	52·375	24·687

(7.) *With reference to the fact that trees grow unequally*, that is, have not an equal thickness of pith round the centre, Mr. Burns, C. E., has the following:—"Take a longitudinal section of the tree cut through the centre so as to show both the convex and concave sides, and it will be found that on the convex sides the fibres are hard and run in nearly straight lines, whereas on the concave side they are soft, and have a wavy appearance caused by vertical compression. Again, cut equal portions from the convex and concave sides of the same tree opposite one another, and dry them thoroughly, and it will be found that the wood from the convex side has a much higher specific gravity than that from the concave side. Again, the wood cut from the convex side is much stronger, and will sustain a greater transverse strain than wood cut from the concave side of the same tree. Again, the wood cut from the convex side of the tree is more durable than that from the concave side. Where Scotch fir, larch, or spruce has been used for roofing, joisting, or flooring, I have always found that the concave side, with the larger fibre, gets worm-eaten and quite rotten long before the other side. These facts I discovered many years ago; a knowledge of which is invaluable to parties using that kind of timber to enable them to know in what direction to cut up the trees for certain purposes."

(8.) " *The resistance of wood* depends upon the three following conditions: —1st. Two pieces of equal length and height offer different resistance with reference to their breadth. 2d. Two pieces of equal length and breadth offer different resistance with regard to their height. 3d. Two pieces of wood of equal height and breadth offer different resistance with regard to their length.

"Again, experience has proved that a piece of wood resting freely with its two ends will carry from one-third to one-half less weight than if the ends are fixed or built in a wall. Old wood has less elasticity than young, and heart-wood is less elastic than sap-wood. The same difference is found with wood from the lower stem compared with that from the upper crown. The elasticity diminishes with the progress of the specific dry weight. Square-cut timbers laid horizontally with their yearly rings have not by far such bearing power as when laid perpendicularly."

(9.) *Bearing capacity of various woods:—*

	Constant.	Wet.	Weight per C. ft.
"Yellow Pine	358·5		25·687 lb.
Baltic Pine	444·		29·062 „
Red Pine	467·		33·437 „
Ash	517·75	53·875	41·812 „
English Elm	595·25		37·312 „
Pitch Pine	629·		45·750 „
American Elm	631·5		45·312 „
American Oak	653·5		44·875 „
African Teak	673·5		60·562 „
Mora	691·		71·250 „
Sabicu	854·25		59·687 „
African Oak	869·5		
Green heart	1,079·5		69·750 „
English Oak	—		53·312 „
Indian Teak	—		38·125 „
Iron Wood	—		73·500 „
English Larch	—		32·562 „

Formula to find the breaking-weight of a piece of timber:—*c* constant, *b* breadth in inches, *d* depth in inches, *l* length in feet, *w* breaking-weight in pounds.

$$\frac{c\quad b\quad d^2}{l} = w.\text{''}$$

J. JUSTEN in *Builder*.

(10.) *Specific gravity of various woods:—*

"Iron wood	1·210	Yew	0·807
Green heart	1·200	Elm	0·800
Sabacue wood	1·100	Apple	0·733
Brazil wood	1·100	Fir	0·657
Ebony	1·080	Lime	0·604
Box	1·050	Cypress	0·598
Medlar	0·950	Cedar	0·561
Lilac or pipe wood	0·930	Poplar (silver)	0·529
Oak	0·885	Sassafras	0·482
Beech	0·852	Poplar (common)	0·383
Ash	0·845	Cork	0·240

"The weight of water for the above is taken at 1,000."

(11.) *Decay of Wood.*—"According to Baron Liebig, the decay of wood takes place in the three following modes—first, oxygen in the atmosphere combines with the hydrogen of the fibre, and the oxygen unites with the portion of carbon of the fibre, and evaporates as carbonic acid. This process is called decomposition. Secondly, we have to notice the actual decay of wood which takes place when it is brought in contact with rotting substances; and the third process is called putrefaction. This is stated by Liebig to arise from the inner decomposition of the wood in itself: it loses its carbon, forms carbonic acid gas, and the fibre, under the influence of the latter, is changed into white dust.

"As an example of this, I refer you to the wooden ceilings of houses which after some time go into that state. The chief cause is, that the free access of the air to the wood is prevented, and the little dampness occasioned by washing is sufficient to promote the dry rot.

"The sap of wood contains partly saccharine matter, which will naturally decompose in itself, and this is noticed in timber stores from the sour taste and smell of such woods.

"The actual time which wood lasts depends in a grant measure on the time when it was felled, and in how far the soil in which it grew was suitable for its development.

"As a rule, the wood cut in summer is less durable than that felled during the winter months."

(12.) *Preserving Timber from Decay.*—"The following plan is said to be common in Burgundy for preserving timber from decay and from insects:— The wood having been steeped for forty-eight hours in a solution of copper —in the proportion of one kilogramme (about 2 lb. 3 oz. and 4 drachms) of sulphate of copper to 20 litres (about one quart) of water—must be allowed to dry in the shade, after which wash lightly with lime. If it does not acquire a bluish green colour, the operation must be repeated. This plan, it is said, is economical, and has been tried with success on fifteen different kinds of wood." * * * "Another economical process of Mr. Fontenay is worth mentioning. He acts upon wood with what he calls metallic soap, which he obtains from the residues in greasing-boxes of carriages; also from the acid remains of oil, suet, iron and brass dust, which are all melted together.

"A piece of wood was put in such a hot fluid for forty-eight hours after the water had previously been partly extracted under the ordinary pressure of the atmosphere. When taken out the metallic solution which it had taken up stood at 3 per cent. to its first weight. This piece of wood was used as a railway sleeper on the Orleans Railroad, and after eight months it was in perfect condition, whilst other wood not treated in similar manner was in a state of decomposition.

"Another process is the following, recommended by Mr. Dondeine, and much applied in France and Germany. It is a paint, consisting of the following:—

Linseed oil	15 kilogrammes.
Resin	15 „
Tar	5 „
Zinc or white lead	12 „
Vermillion, red or yellow	10 „
Colour (clay colours must be avoided as they thicken too much)	4 „
Cement	6 „
Oxide of iron	8 „
Gutta percha, glue, or gum	2 „
Hydrate of chalk	6 „
Lard	15 „
Litharge	2 „

(One kilogramme = 2·205 lb. English).

All these are well mixed, and reduced by boiling to one-tenth. When applied warm it may be used with a brush; but not too hot. It may also be used cold; in which case the paste must be mixed with a little varnish or turpentine oil. The results obtained with this process are reported as yet very satisfactory. It prevents decay, and admits no humidity.

"Mr. Dondeine further reports that it prevents oxydation of iron; and wherever walls have had a coat of this mixture it has kept away all wet, and unpleasant insects, ants, bugs, &c. Roofs of pasteboard or of wood which have been painted with the mixture keep dry, and withstand the effects of rain and snow.

"Wood impregnated with sulphate of copper will not last longer in sea-water than other wood. It is quite as much attacked by the sea worm as when in its natural state. On the other hand it has been proved that wood impregnated with sulphate of copper will have longer durability in the soil than when either tarred or charred."—*Journal.*

(13.) *A Snow Board for Roofs.*—" Mr. Benjamin Dixon of Limehouse, (a member of the Metropolitan Board of Works,) has recently invented a contrivance to prevent the flooding of the roofs of houses at the breaking up of a frost, by allowing a fresh current for the snow water as it dissolves. The invention is very simple in its nature, but by practical men who have examined it is highly spoken of. It consists of a flat piece of wood, having a number of perforations (the holes being counter-sunk below), resting upon and fastened to two slips of fir, one on either side, the slips being about an inch in depth, and having small openings running along them on both sides at distances of from eight to ten inches. The Snow Board being made, is placed loosely on the gutter of the roof near the centre, thus making a free passage for the gradual conveyance of the water to the hoppers of the ordinary pipes. This snow board should be made of inch yellow deal, the cost of which is trifling, it being only from 3d. to 4d. per foot run, and should not be fixed on the lead or zinc, but be placed loosely, so that it may easily be taken off, and the gutter cleaned at any time. It ought not to be painted, and may with advantage be used in the summer months to prevent the heat from cracking the lead."—*Journal.*

(14.) *Plastic Wood.*—"One of the results of the late French treaty has been the introduction into this city of a new product of art and industry, called 'bois duré,' which will cause quite a revolution in the manufacture of many articles of ornament and general use, and, to judge by the remarkable applications that we have seen, the discovery is a great success. 'Bois duré,' or hardened wood, which has been improperly described as wood softened and then hardened, is made from sawdust, which, under the influence of a high temperature and the enormous pressure of 600 tons, acquires a hardness a good deal exceeding that of wood. It is of a very fine grain, and fears no atmospherical variation; but its principal merit is its adaptation to moulding, and by the most economical processes forms and impressions are given which would require, in any other way, considerable labour and workmanship. We have seen various articles of great beauty manufactured from it, such as writing-desks, inkstands, seal-handles, medallions of royal and public characters, and even binding for books; on these, carving and the most delicate sculpture are reproduced with the perfection of models, and with exquisite fineness of execution. In Manchester there are one or two places where the products of this new art can be seen."

(15.) *To prevent Sounds through Folding-doors.*—In answer to a query on the subject, the following were sent to the *Builder*:—"Double doors are the best preventive; but as these will be expensive, introduce a roller-blind, same construction as ordinary blinds, cover the roller with Croggon's noiseless felt: the bottom slip should be covered inside with thin sheet lead; attach small rings to each side, to work over a vertical iron rod. This will not be expensive, and can be attached, detached, or drawn up or down in a few minutes." * * * *Folding Doors.*—"The best alternative to intercept the sound and to keep out the noise where there are folding doors, separating two rooms, would be double curtains of some woollen texture, viz., one to each room."

(16.) *Herring-bone and Improved Strutting for Floors.*—"Mr. New, at a meeting of the Architectural Association, said he would begin by referring to herring-bone strutting. Double-framed floods had been mentioned in the excellent paper read that evening, and he was very glad to find they were getting into disuse, except when floors were on a very large scale. To meet that difficulty there had been invented an expedient to prevent the expanding of timbers when they had only single timbers, and the expedient was to use herring-bone or cross-strutting. He did not approve of herring-bone strutting, for he had frequently found when there was a pressure on the floor portions of it gave way. To obviate that difficulty he had used a solid strutting the same depth as the timbers. He placed the sölid strutting between the floors, and if there was a floor where he thought there was to be a considerable weight he passed a rod right through it. He had found that that kind of floor would stand any amount of compression, with solid strutting between the timbers in a wedge-like form, and, if requisite, a double or triple strutting. He was one of those who objected to heavy timbers, and in favour of using light timbers. It was the proper application of the timber they ought to look to principally, as well as its adaptation to the purpose in hand. He considered two inches or two inches and a quarter quite sufficient for any floor they wanted to carry a weight. If he wanted to strengthen a floor he strengthened it crosswise by solid strutting, and drew it up by tension rods. It was necessary they should make partitions self-supporting—they should never bear on the timbers of the floor; every partition ought to have its trussing. He advised that the partition be in every case supported with an intertie and trussed. The speaker then referred generally to the subject of the construction of roofs, the proper discussion of which, he said, would occupy an evening. In the construction of a roof the great thing they had to contend against was the expandage or compression outside. Mr. New illustrated his remarks by a number of diagrams."

SECTION FIFTH.—TERMS USED IN PLASTERING.

Angle float.—A float made to the internal angle of two sides of a room.

Bastard Stucco.—Three coat plaster, the first the roughing in or rendering; the second floating as to trowelled stucco; the third or finishing contains a little hair besides the sand.

Bay.—A rib of plaster formed between the screeds for regulating the floating rule.

Coarse stuff.—See *Lime* and *Hair*.

Coat.—A layer or thickness of plaster work done at one time.

Compo, used in outside work, and implies the incorporation of all the parts used with Roman or other patent cements.

Derby.—A two-handed float.

Dots.—Patches of plaster used to regulate the floating rule in making screeds or bays.

Fine Stuff, composed of slaked lime sifted through a fine sieve mixed with a proper quantity of hair, and sometimes a small quantity of sand.

Finishing, the third coat in three-coat work for stucco; the term setting is used when the third coat is of fine stuff for papering.

First coat,—In two-coat work is called laying if done on lath, and rendering if on brick; in three-coat work it is called pricking up when on lath, and roughing in when on brick.

Float.—A tool used to form the second coat of three-coat work to a proper surface.

Floated lath and plaster,—Set fair for papering is three-coat work—the first called pricking up; the second, floating; and the third or setting coat of fine stuff is understood to be pricked up, as there is no floated work without being pricked up.

Floating Screed.—See *Screeds.*

Gauge.—A mixture of plaster and fine stuff, or of plaster and coarse stuff used for running mouldings, and for the finishing coat of principal ceilings.

Hawke.—A square piece of board having on the under side a projecting handle, and used for holding the plaster.

Laths.—Strips of wood nailed to the ceiling joists and quarters of partitions, having small spaces left between to form a key for the plaster formed by the inequality of the edges. They are of different lengths and thicknesses—are called single laths, lath and half, and double laths; they are called three-foots and four-foots according to length.

Lath layed and set.—Two-coat work, the laying or first coat is not scratched unless with the points of a broom.

Lath floated and set—same as lath pricked up, floated, and set.

Lath plastered, set, and coloured—same as lath layed, set, and coloured.

Laying.—The first coat on lath of two-coat work or set work, the surface is roughed with a broom and not by scratching.

Laying on Trowels, used for laying on plaster.

Lime and hair.—A compound of lime and hair used in the first coat and in floating; it is also called coarse stuff.

Mitering Angles.—Making good the internal and external angles of mouldings.

Mouldings are worked as follows:—When of large girt they are first worked with coarse stuff and filled with tiles, &c., and then run with coarse gauge, fine stuff gauge, putty gauge, and finished with raw putty. When of moderate dimensions they are first run with coarse guage, then with fine stuff, then with putty and plaster, and finally, with raw putty.

Plaster.—A material used for casting ornaments, and with which the fine stuff of gauge is mixed.

Pricking up,—On lath is the first coat of three-coat work. The materials employed are, coarse stuff mixed with sand or road drift, and its surface is always cross-scratched to form a key for subsequent coats.

Putty.—A fine cement made of lime only.

Rendered and floated; three-coat work, commonly called floated, rendered, and set.

Rendered and set, same as set work.

Rough Cast.—An outside covering cheaper than stucco. It consists of a pricking up coat of lime and hair, a second coat worked smooth, and afterwards splashed over with roughcast, which is composed of fine gravel, with the earth cleanly washed from it, and well incorporated with lime and water.

Roughing in—the first coat of three-coat work.

Rough Stucco.—See *Stucco.*

Rough rendering; means one coat rough.

Second coat.—The finishing coat inlayed and set, or inrendered and set, or called the floating when roughed in, floated, and set for paper.

Screeds.—Wooden rules for running mouldings; also the guides in plaster formed on the margins of walls and ceilings for floating.

Set fair, used after roughing in and floated, or pricked up and floated.

Setting.—Stuff that has to harden in a short space of time.

Setting coat; in best work is a mixture of putty and plaster; in common work it consists of fine stuff.

Set work.—Two coat upon lath.

Stopping.—Making good to cracks, &c.

Stucco or finishing, the third coat of three-coat plaster, rough ditto, is that finished with stucco, floated and brushed.

Third coat, the stucco for paint or setting for paper.

Three-coat work.—Pricking up or roughing in, floating and finishing.

Trowelled stucco for paint; same as roughed in for brickwork.

Two-coat work, either layed and set or rendered and set.

Work.—The coating of plaster layed and set, and on brickwork where there are two coats only.

SECTION SIXTH.—TERMS USED IN SLATEING, &C.

Back of a Slate.—The upper side of it.

Backer.—A narrow slate placed on the upper side of a broad square-headed slate, where the slates begin to get narrow.

Bed of a Slate.—The lower side of it.

Bond or lap.—The distance between the lower edge of the upper slate and the nail of the under.

Cresting.—Ornamental ridge tiles.

Eave.—The lower part of the slate-covering projecting over the face of the wall.

Holing.—Forming holes in the slates for the admission of nails.

Margin of a course.—Those parts of the upper side of slates exposed to the weather, or showing externally.

Nails.—Form of ordinary clout nails, either of copper, metal, or zinc.

Patent Slates, used without boarding, and screwed to the rafters, and having slips set in putty to cover the joints.

Scantle.—A gauge for regulating the proper length of slates.

Sorting.—Determining the length of slates by the scantle.

Squaring.—Cutting true the sides and bottom of a slate.

Tail.—The lower end of a slate.

Trimming, same as squaring.

Tiles.—Artificial roof coverings. Plain tiles are rectangular in form. and flat, they are about 10½ in. long, 6 in. broad, and ⅝ths thick. Ridge tiles are of a semi-cylindric form, and used for covering ridges—they are about 12 in. long, 10 in. broad, and ⅝ths thick—those covering the angle, formed by two sloping sides, are called hip tiles.—Pantiles, have each surface concave and convex hung on the laths by means of a lip or projection on the under side of the upper end; size about 14 in. long, 10 in. broad.

SECTION SEVENTH.—TERMS USED IN PLUMBING, PAINTING, &C.

Drips in Gutters or Flats are formed at the joints of lead in gutters, by turning up the edge of one piece of lead, and dressing down the other over it.

Flashings are pieces of milled lead about 9 inches wide, and are fixed round the extreme edge of a flat or gutter in which lead has been used, one edge dressed over the lead, and the other passed into the joints of the brickwork, also used round chimney stacks, hips, ridges, and valleys.

Laying lead.—The operation of covering flats, &c., with lead where joints are necessary. They are effected by having rounded wooden rolls placed under the joints of the lead, and dressing one of the edges over the roll on the inside, and the other over both on the outside.

Pipes.—Leaden tubes of various sizes for conducting or carrying off fluids.

Pumps are of various kinds—such as lifting, forcing, &c.

Soil pipe.—Large leaden pipe for conducting the soil from water-closet apparatus to the drain.

Traps.—Contrivances to prevent the escape of effluvia from drains, &c.

Bringing forward.—Priming and painting new or old work so that the whole shall have the same appearance when finished.

Clearcole and finish.—The cheapest kind of painting consists of—first, cleaning the work and filling up with putty all holes, cracks, &c.; it is then painted over with a coat of whiting and size, and afterwards with a coat of lead oil colour called the finish.

Graining.—Imitating, by means of painting, all kinds of rare and expensive woods.

Marbling.—The imitation of marble by same process.

Three times and Flat.—Three coats oil colour, one of turpentine—generally used for new work.

Thrice in Oil.—Twice in oil and once in colour mixed with turpentine.

Twice in Oil, is when the work is painted twice over in oil colour.

PRACTICAL NOTES AND MEMORANDA UNDER SECTIONS FIFTH, SIXTH, AND SEVENTH.

(1.) *Tin-lined Lead Cisterns and Pipes.*—"At a meeting of the Liverpool Chemists' Association, specimens of lead-pipe and sheet lead, electro-plated with tin, were exhibited by Mr. Holt, and some discussion ensued respecting the use of lead coated in this manner for water-cisterns and pipes. It appeared to be the opinion of the meeting that the coating of tin, instead of preserving the lead, was far more likely to insure its more rapid corrosion; for if the coating of tin by any means happened to be scratched off, even to the slightest extent, galvanic action would take place, and the lead would be destroyed very quickly. Dr. Nevins and Dr. Edwards stated that their experiments had proved that such would undoubtedly be the case; Dr. Edwards remarking that, in one case which he had examined, a cistern made of lead, in which was an accidental admixture of tin, was eaten out by well-water in six months, the lead being rapidly precipitated in the form of sulphate, &c."

(2.) *Dirty Water-cisterns.*—"At the risk of being considered a sanitary bore, I must again call attention to water-cisterns; for, within the last fortnight, I have seen two in a dreadful state. One of them was at a large hotel, and always in use. At the bottom of this cistern there were 2 or 3 inches of muddy sediment, which, every time the water came in, was disturbed, and mixed with the water. The other was at a private house; and, when I took off the cover of the cistern, the lady of the house was frightened at the state it was in, and beseeched me to clean it out directly; but it was not near so bad as one in the same house, and which she could not see, as it was built under the floor of the water-closet. It is almost useless for the water companies being compelled to cover their reservoirs, and get their supply from a pure source, if people allow the water to be polluted after they get it in their house, by having no covers to the cistern, and not having them cleaned out oftener; and there are hundreds of cisterns built in such out-of-the-way places, that many people live in the house for years without knowing where they get the water from: therefore illness often results. I think, if public attention were directed by the officers of health of the different parishes, by handbills, something like those in the hot season in reference to the muzzling of dogs, it would be of advantage to the public health."—A Workman in *Builder*.

(3.) *Delivery of Water by Pipes.*—"The greatest delivery with a straight pipe will be attained with a length equal to four diameters, the result being one-third more than the delivery through a plain hole; the discharge decreases as the pipe is increased beyond that length, until at a length of 60 diameters, when it again equals the discharge through the plain orifice, it is probable that if a pipe with curved decreasing taper were to be tried, the delivery through it would be equal to the theoretical discharge, which is about 1·65 the actual discharge through a plain hole."

(4.) *Solders.*—Holtzappfel gives the following receipts:—"Pewterer's solder—two parts of bismuth, four parts of lead and three of tin; or one part of bismuth, one of lead, and two of tin. Soft spelter's solder—equal parts of copper and zinc. Coarse plumber's solder—one part of tin, three parts of lead; or two parts of tin, and one part of lead."

(5.) *Form of Gas Fittings.*—"It is, I am convinced, an erroneous practice of many of the manufacturers of gas-lighting apparatus, to bestow much labour or expense in the conspicuous ornamentation of the chandelier, brackets, or other appliances, intended for carrying the gas-burner: as long as we were obliged to use such weighty articles as candles, or vessels of oil, which required conspicuous articles for their support, it was desirable to make these ornamental, or at least to endeavour that they should not be unsightly; but with gas it is far otherwise, we have next to no weight to support, and should endeavour, as far as possible, to imitate the celestial luminaries, so that nothing but the *light* should be visible: an approach to this is done in the case of the sun-light, and some few other forms of gas-light, but it appears as yet to be but little considered, that the first object of the introduction of gas should be to give light for other purposes than to illuminate or to attract attention to the workmanship of the chandelier or other apparatus, which should, if possible, be entirely unseen, or as little conspicuous as possible."—*Builder*.

(6.) *Paper-hanging—On Arsenical Paper-hangings.*—"I procured from the shop of Messrs. Marratt and Short, opticians, 63 King William-street, London-bridge, a quantity of dust for the purposes of analysis. The walls of this shop are covered with an unglazed arsenical paper, and, as I am informed, they have been so covered for a period of three years. In collecting this dust from the tops of the instrument-cases, great care was taken not to touch the walls. The quantity thus collected for examination amounted to about 450 grains. It was nearly black, and under the microscope it appeared to consist of fibres and sooty particles. It was very light and flocculent. 150 grains of the dust were examined by Reinsch's process, and enough metallic arsenic was obtained from this quantity to coat about 10 square inches of copper-foil, in addition to a piece of copper-gauze. From the deposit on the latter, by the application of heat, octahedral crystals of arsenic were readily obtained. The cases had not been dusted for a period of nine months. These facts lead to the inference that the air of a room, of which the walls are covered with an unglazed arsenical paper, is liable to be charged with the fine dust of the poisonous arsenite of copper. Those who inhabit these rooms are exposed to the risk of breathing this dust. The poison may thus find its way by the pulmonary membrane into the system, or it may affect the eyes, nose, and throat by local action."—Dr. A. S. Taylor.

7. *Glazing.—Fairbairn and Tate's experiments upon glass:*—"The glass experimented upon was of three kinds:—

	Specific Gravity.
Best Flint Glass, ...	3·0782
Common Green Glass, ...	2·5284
Extra White Crown Glass, ...	2·4504

Tenacity of Glass.—For reasons detailed by the authors, the experiments upon the direct tenacity of glass made by tearing specimens asunder are less satisfactory than those in the rest of the paper; and it is argued that more reliance is to be placed upon the tenacity deduced from the experiments on the resistance of globes to bursting, in which water-pressure was employed, than upon the tenacity obtained directly by tearing specimens asunder. The results obtained by the latter method give the following mean results:—

	Tenacity per square inch in lbs
Flint Glass, ...	2413
Green Glass, ...	2896
Crown Glass, ...	2346

Resistance of Glass to Crushing.—The experiments in this section were made upon small cylinders and cubes of glass crushed between parallel steel surfaces by means of a lever. The cylinders were cut of the required length from rods drawn to the required diameter, when molten, and then annealed, in this way retaining the exterior and first cooled skin of glass. The cubes were cut from much larger portions, and were in consequence probably in a less perfect condition as regards annealing. Hence, as might have been anticipated, the results upon the two classes of specimens, although consistent in each case, differ widely from one another.

The mean compressive resistance of the cylinders, varying in height from 1 to 2 inches, and about 0·75 inch in diameter, is given in the following table:—

Description of Glass.	Height of Cylinder in inches.	Mean crushing-weight per square inch.		Mean crushing-weight per square inch.	
		In Pounds.	In Tons.	In Pounds.	In Tons.
Flint Glass,	1	29·168	13·021	37·582	12·313
	1·5	20·775	9·274		
	2·0	32·803	14·644		
Green Glass,	1	22·573	10·081	31·876	14·227
	1·5	35·029	15·628		
	2·0	38·105	16·971		
Crown Glass,	1·0	23·181	10·348	31·003	13·840
	1·5	38·825	17·332		

The specimens were crushed almost to powder by the violence of the concussion; it appeared, however, that the fracture occurred in vertical planes, splitting up the specimen in all directions. Cracks were noticed to form some time before the specimen finally gave way; then these rapidly increased in number, splitting the glass into innumerable prisms, which finally bent or broke, and the specimen was destroyed.

The following table gives the results of the experiments upon the cut cubes of glass:—

	Mean Resistance to Crushing.	
	In Pounds.	In Tons.
Flint Glass, ...	13,130	6·861
Green Glass, ...	20,206	9·010
Crown Glass, ...	21,867	9·762

Hence, comparing the results on cylinders with those on cubes, we find a mean superiority in the former case in the ratio of 1·6 : 1, due to the more perfect annealing of the glass."—*Transactions of the Royal Society.*

8. *Blinds for ensuring Cool Rooms.*—"It may be interesting to your numerous readers to learn, since in fevers a cool room frequently does as much good as medicine, that blinds, coated with the following composition, and placed *outside* the window, are both sun and rain proof. The greatest heat will not affect them. Boil well together two pounds of turpentine, one pound of litharge in powder, and two or three pounds of linseed oil; the blinds are to be brushed over with this varnish, and dried in the sun. Umbrellas, light linen coats, and covers of hats, may be so treated."—*Lancet.*

ARCHITECTURAL DESIGN AND BUILDING CONSTRUCTION.

9. *Reflectors of Light for Houses.*—"In the narrow streets of Genoa a reflector is used, made of clean white cotton or linen cloth, attached to a framework of wood, or to a couple of iron rods, secured to brackets of iron, one rod being at the top, the other at the bottom of the brackets, and placed at an angle of 45° with the window, the apex of the angle nearly touching the window, and, of course, turned downwards, the reflector itself being of the breadth of the window at the least, and of about 3 feet or more in depth. The shops on the ground floor have the reflector fixed towards the upper part of the window, in order to leave the lower part free for exposing the articles that may be for sale. A correspondent of the *Morning Advertiser* suggests the use of such reflectors in houses and in other buildings situate in the narrow streets of our own towns or villages. The adoption of such a plan generally and at once would create employment for many a cotton-loom now idle."—*Builder.*

(10.) *Slates.*—"The following gives the sizes, average weight, and prices of the various commercial dimensions :—.

Description.	Size.	First Quality.			Second Quality.	
		Average Weight.	Estimated Surface.	Price.	Average Weight.	Price.
				£ s. d.		£ s. d.
Queen's, . .	32, 34, 36 in. by 16, 17, 18 in.	……	Per ton, .	2 6 0		
Princesses, .	30 by 15 in.	115 cwt. per 1,200	16¾ sq. per 1,200	12 10 0		
Do., . .	28 „ 14 „	97 „ „	14¼ „ „	10 10 0		
Do., . .	26 „ 13 „	82 „ „	12½ „ „	9 0 0	cwt.	
Duchesses, .	24 „ 12 „	65 „ „	11 „ „	7 15 0	80 per 1,200	6 12 0
Marchionesses	22 „ 11 „	54 „ „	9 „ „	6 0 0	65 „ „	5 4 0
Countesses, .	20 „ 10 „	43 „ „	7¾ „ „	5 4 0	51 „ „	4 1 6
Viscountesses,	18 „ 9 „	35 „ „	6 „ „	3 6 6	40 „ „	2 13 0
Ladies, . .	16 „ 8 „	25 „ „	4¾ „ „	2 7 6	……	1 17 6
Small Ladies,	14 „ 7 „	19 „ „	3½ „ „	1 0 0	……	0 16 0
Doubles, . .	12 „ 6 „	13 „ „	2½ „ „	0 12 0	……	0 10 6
Imperials, for roofing, various lengths,	5 to 7 in. wide,	……	Per running foot,	0 0 0¾		
Do., . .	8 to 10 „	……	„ „	0 0 1		
Rags, . . .		17 doz. per ton,	2½ sq. per ton,	0 1 11	20 doz. per ton,	0 1 0
Scantle, . .	Various sizes,	13 cwt. per 1,000	1½ „ per 1,000	0 8 0		
Common, . .	„	20 „ „	1 „ „	0 5 0"		

Trimming Slates.—"I was pleased a short time since to observe the manner in which some slaters were 'punching' *two* slates, for one, under the usual mode; which old mode consists of marking with a gauge the slates where they have to be punched (this takes quite as long as the punching). Their new mode of operation was to sit astride a plank, nail two pieces of wood thereon at a given distance apart, say 10 inches for duchess; in this manner they knew instantly where to punch the slate. I think if you were to make this known it would be of service to the trade. The men said it was their 'patent.'"—L. F. in *Builder.*

(11.) *Artificial Stone.*—"Inquiries," says the *Building News,* "reach us from time to time for information respecting the various kinds of artificial stone. It seems desirable to answer such interrogations at once, and rather fully, which we shall do, availing ourselves largely of the data given in Dr. Ure's admirable 'Dictionary of Arts,' &c. It appears that artificial stone has been made with great success for some years at Berlin, by Mr. Feilner, for statuary and other ornamental accessions to architecture. The materials employed by him are nearly the same as those used in the production of English pottery. The kilns employed are said to be economical in fuel, and deserve to be better known. Among the numerous modes proposed for this manufacture but very few may be said to have met with much success, the failures being generally either on account of too costly production, or want of durability. Among those systems which have failed from one or other of these causes, that of Mr. Buckwell's may be mentioned; it is, in point of fact, a perfect kind of concrete. The mould is filled with fragments of stone of suitable size, filling up the interstices with stones of smaller dimensions, when a liquid cement, a mixture of chalk and Thames mud, or Mersey mud burnt together, is poured in, and the whole subjected to pressure, which forces out the water through apertures left in the mould for that purpose; the resulting composition is very perfect, and is of such hardness that it rings when struck. Another process is that employed at the Dippenhall Silica Works at Farnham. It is founded on the employment of soluble silica, being that kind of silica which is readily dissolved by boiling in open vessels with solutions of caustic potash or soda, as distinguished from the silica of flint, which is only soluble in such solutions at a temperature of about 300° Fahr. in a steam-tight boiler, and from that of quartz or sand, which is insoluble by any ordinary process. Messrs. Payne and Way, upon ascertaining the existence of such silicate, took out a patent for 'Improvements in the Manufacture of Burned and Fired Ware.' They lay claim in their specification to the production of a superior class of burned goods by using the 'soluble silica,' with such admixtures of clay or lime as may be required. By this means they propose to make any kind of artificial stone more or less resembling natural stone; blocks or slabs, building bricks of any colour, and fire-bricks. They also consider that in some cases articles may be burned to a slight degree of hardness, then finished up by the use of tools, and afterwards reburned to any hardness that might be required. Mr. Payne's death in 1858 has considerably retarded improvement in the process, so that the results at the present time are not so satisfactory as might fairly have been expected."

(12.) *Relative Strength of Cements.*—"Some experiments have been made in Liverpool on the relative strength of Portland cement as manufactured by the experimenters, and what is known as Roman cement. According to the *Liverpool Journal,* all the experiments were made on cement bricks, having a sectional area of six square inches, and these were submitted to a strain tending to tear them asunder by weights placed in a scale-board, suspended by clamps attached to the bricks. The following are given as the results of the experiments :—

	Age of Brick.	Conditions of Mixture.	Breaking Weight.
		ROMAN CEMENT.	
No. 1,	3 weeks,	Roman Cement, neat,	476 lbs. strain.
No. 2,	3 weeks,	1 of ditto to 1 of Sand,	420 lbs. strain,
		PORTLAND CEMENT.	
No. 3,	3 weeks,	Portland Cement, neat, immersed in water within 1 hour after gauging for 24 hours,	1,521 lbs. strain.
No. 4,	3 weeks,	Portland Cement, neat, not immersed in water,	1,372 lbs. strain.
No. 5,	3 weeks,	Portland 1 part, Sand 3 parts,	420 lbs. strain.

In respect to experiment No. 3, it is but right to state that the breaking of the brick did not take place by mere suspension of the weight attached to it, but was effected by a jerk, which many of the old gentlemen present considered would not be over-estimated at 168 lbs. additional to the weight suspended.—*Builder.*

(13.) *Bronzing of Plaster.*—"Plaster of Paris, paper, wood, and pasteboard, may be made to resemble pretty closely the appearance of articles of real bronze, modern or antique. The simplest way of giving a brilliant aspect of this kind is with a varnish made of the waste gold leaf of the beater, ground upon a porphyry slab with honey or gum-water. A coat of drying linseed oil should be first applied, and then the metallic powder is put on with a linen dossil. Mosaic gold, ground up with six parts of bone ashes, has been used in the same way. When it is to be put on paper, it should be ground up alone with white of eggs or spirit varnish, applied with a brush, and burnished when dry. When a plate of iron is plunged into a hot solution of sulphate of copper, it throws down fine scales of copper, which, being repeatedly washed in water, and ground along with six times its weight of bone ashes, forms a tolerable bronzing. Powdered and sifted tin may be mixed with a clear solution of isinglass, applied with a brush, and burnished or not, according as a bright or dead surface is desired. Gypsum casts are commonly bronzed by rubbing brilliant blacklead upon them with a cloth or brush."—*Building News.*

(14.) *Securing Ceilings.*—"A patent has been taken out for securing the plastering of ceilings and walls. The object is to cause the first layer of plaster to adhere as firmly to the laths as the second layer does to the first, and for that purpose it consists in applying to the joists or grooves, or to a ceiling of boards, laths having inclined edges, forming an angle with the horizontal plane of the floor, to which the mortar is to be applied, and spread on in the usual manner, so that the tongues of mortar which pass between the interstices of the laths form an angle with the horizontal plane of the floor, and overlap the tops, and are clinched thereto, whereby the mortar is held and prevented from falling."

(15.) "*Fire-proof Composition to resist Fire for Five Hours.*—Dissolve in cold water as much pearlash as it is capable of holding in solution, and wash or daub with it all the boards, wainscoting, timber, &c. Then diluting the same liquid with a little water, add to it such a portion of fine yellow clay as will make the mixture the same consistence as common paint; stir in a small quantity of paperhanger's flour paste to combine both the other substances. Give three coats of this mixture. When *dry,* apply the following mixture :—Put into a pot equal quantities of finely pulverized iron filings, brickdust, and ashes; pour over them size or glue water; set the whole near a fire, and, when warm, stir them well together. With this liquid composition, or size, give on coat, and on its getting dry give it a second coat. It resists fire for five hours, and prevents the wood from ever bursting into flames. It resists the ravages of fire, so as only to be reduced to coals or embers, without spreading the conflagration by additional flames, by which five clear hours are gained in removing valuable effects to a place of safety, as well as rescuing the lives of all the family from danger! Furniture, chairs, tables, &c., particularly staircases, may be so protected. Twenty pounds of finely-sifted yellow clay, a pound and a half of flour for making the paste, and one pound of pearlash, are sufficient to prepare a square rood of deal boards. When the Chinese were told the risk we ran of being roasted alive in our many-storied mansions, they remarked, 'What little land the English must possess that compels them to build such *high* houses.'"—J. B. N in *Builder.*

(16.) *Seaweed for Lining Walls.*—"M. E. Legou recently presented a report to the Paris Academy of Sciences with a view of showing the value of seaweed applied in layers against the thin walls of habitations to prevent sudden variations and excess of temperature; the marine algæ, such as seawrack, he considered, might be looked upon as a kind of sea-wood, which has this advantage over ordinary wood, that it does not harbour insects, and undergoes little change by dryness or humidity, provided it be sheltered from the direct action of the sun. If exposed to the sun it changes from being brown and flexible to a light colour and almost rigid. In darkness, on the contrary, as M. Legou states, it is unchangeable, unfermentable, imputrescent, uninflammable, and unattackable by insects. At first it has an objection, inasmuch as it is hygrometic, but it is found that a single thorough good washing in fresh water removes the salt, and then its properties become so beneficial that a well-known French architect has styled it the 'flannel of health for habitations.' It appears to have been supplied with success between the tiles and ceiling of a railway station, also in a portable house intended for the use of officers at the camp of Chalons. Double panels, the intermediate space being filled with seaweed, have also been prepared for the construction of temporary barracks at the Isle of Reunion. Seaweed has been long used in England for filling beds or mattresses, and would seem to justify some of the encomiums bestowed upon it by M. Legou; at any rate it is worth a trial, and you may find it the very 'cheap and lasting material' you want."—*Building News.*

(17.) *Experiments with Paint.*—"We extract from the *Scientific American* the following interesting account of experiments made with paint, with a view to test the comparative durability of certain pigments, and the vehicles employed with them in house painting. Mr. J. Ewer, jun., of Williamsburg, L.I., United States, says :—"During the last twenty-three years he has been practically engaged in house and sign painting, and in that period many questions had been asked of him regarding the best paints to use. 'To these,' he says, 'I gave the best answers that a general and superficial observation would warrant; but not being reliably answered, they increased fourfold as the zinc paint came to be generally used. It was at this time (September, 1851) that a method of demonstration suggested itself. I forthwith procured two strips of board, and marked them into compartments, and after numbering them 1-2, up to 11, I coated them in the following manner:—No. 1 received two coats of white lead mixed with raw linseed oil, and no dryer; the paint was laid off or finished with the brush, stroked up and down. No. 2 received the same coating of material as No. 1, but was finished with the brush passed right and left, crosswise. No. 3 was given two coats of white lead, raw linseed oil, and considerable spirits of turpentine in the first, but only a little in the last coat. No. 4 received two coats of white zinc and raw linseed oil—all mixed with what is called 'patent dryer.' No. 5 the same as No. 4, but with no patent dryer. No. 6 received a first coat of white lead and Paris white, equal parts, and clear white lead for the last coat, with raw linseed oil as the vehicle. No. 7 was given two coats of white lead, with *boiled* linseed oil. No. 8 three very thin coats of white lead, with raw linseed oil. No. 9 got a very heavy prime coat of white lead, and a very thin second and last coat, with raw linseed oil. No. 10 the reverse of No. 9, namely, a thin prime coat, and a heavy finishing one. No. 11 received two coats of Paris white and white lead, equal parts, with raw linseed oil. After this was accomplished, and the paints well dried, the two pieces of board were placed in a position where they were exposed to the weather—its sunshine and its storms—for years.' "

The following are the results obtained:—"The white lead paints exhibited a decided superiority for durability over the zinc, and the squares finished with the brush up and down in vertical lines are decidedly superior to the one laid with the brush right and left. (This is undoubtedly due to the moisture being allowed to flow down more freely than in the square finished with the brush run transversely, which left small cross ridges of the paint.) No. 9, which received a very heavy prime coat, is white and chalky; No. 10 is darker in colour, but not so chalky; No. 11 is superior to the two preceding numbers. Of all the squares, however, No. 7, consisting of two coats of white lead, with boiled linseed oil, is by far the best—the smoothest and closest.'

The experiments are valuable, because they afford positive data regarding paints, and the manner of applying them to the outside of buildings, so as to obtain the best effects. The coating of white lead, with raw linseed oil and a little spirits of turpentine, looks well. Raw linseed oil, in white lead, without turpentine, imparts a greasy appearance to white paint when first put on; a little turpentine, therefore, improves its appearance, but care must be exercised not to add too much, because, when in excess, it imparts a saponaceous character to the paint, which makes it become chalky, and scales off rapidly by exposure to rains and winds."

(18.) *Adulteration of White Lead with Barytes.*—"Barytes is said to be valuable in the manufacture of fine earthenware; but, in reality, very large quantities are ground in oil, and sold in barrels at about £4 10s. a ton, as a substitute for, or to mix with white lead. Some of the painters in Glasgow use it constantly. It is also used by some masons in their putty for joints in ashlar work.

"This mineral is extensively wrought at Muirshields, near Lochwinnoch, in Renfrewshire; also in the island of Arran. At the former place extensive works are in operation for grinding and bleaching it. The working of this mineral must be a valuable source of revenue to the proprietors, who, of course, cannot help its being put to bad uses. After the paint has been used the adulteration is difficult to detect *at first*, especially in flat tints (that is, when unglazed); but, of course, it *very soon* appears. The presence of barytes in oil paint may be detected by rubbing the paint between the finger and thumb for a little time, when it becomes *granular;* whereas, white lead paint does not. Barytes in place of white lead, and petroleum in place of turpentine, account for low estimates and bad work."—DETECTOR, in *Builder.*

(19.) *Destructive Effects of Red Lead upon Iron.*—"Mr. Robert Lamont has reported to the managers of one of the largest steam-packet companies in Liverpool, that the use of red lead for coating iron vessels is most pernicious. In this he is confirmed by the opinion of Mr. Nathan Mercer, F.C.S. The red lead coating gets covered with blisters, from each of which, on being opened, a clear fluid escapes, and leaves exposed on the surface of the iron a number of brilliantly-shining crystals of metallic lead. Mr. Mercer says each blister is, in fact, a galvanic battery in miniature; and that as, wherever there is electrical there must also be chemical action, the corrosion is easily accounted for. This action, he says, will continue as long as any red lead remains, and is necessarily at the expense of the iron. 'Sweating' is due, in a great degree, to the use of red lead paint in immediate contact with iron."

(20.) *New Mode of Staining and Figuring Wood.*—"At the Liverpool Polytechnic Society's first meeting for the season some samples of ornamented wood were submitted for inspection. The process was described as follows:—The deals, veneers, or planks, as they come from the saw, are placed on a solid frame, and fastened down, after which an engraved roller, heated to a temperature suited to the quality of the wood, is passed over them, the pattern being thus burnt in. The surface is then planed smooth and French-polished, leaving an effect, it was said, equal to that of the finest painting or staining. Several members wished to know the cost at which the work could be done, but no one present was in a position to answer the question. The chairman stated that the maker (a Mr. King, of Clayton-square) was busily at work with the invention."

(21.) *Contrasts in Painting.*—"Avoid blazing contrasts of colour, such as bright red, next bright green or bright blue, next bright yellow, such contrasts are not harmonious. Let one of the two colours always be subservient to the other. It is not so much what colour a material is, but how that colour is made to appear. It is necessary to bear in mind that all colours have their complementaries, which add to or detract from the beauty of the adjoining colours, according to what they may be. Thus, the complementaries of red are green; of blue are orange; of yellow are violet. If you cut out pieces of grey paper in an ornamental form, and stick a piece on each of the three colours I have named, you will find in a shaded light the grey will be fully tinted by the complementaries of these colours. But you cannot lay down precise rules. An experienced artist can bring any two colours together by properly modulating them.

Nothing is so charming and so refreshing to the eye as an harmonious arrangement of colours; they are "like a sweet chord of music to the sense." The hand of nature never errs, whether it brings together scarlet and crimson, as in the cactus; scarlet and purple, as in the fuschia; yellow and orange, as in the calceolaria; or the colours in the varied plumage of exotic birds—the harmony is always beautiful, ever perfect. The laws of harmonious colouring are a necessary part of the knowledge of the manufactures of coloured fabrics.

I will suggest a few contrasts—1. Black and warm brown. 2. Violet and pale green. 3. Violet and light rose colour. 4. Deep blue and golden brown. 5. Chocolate and bright blue. 6. Deep red and grey. 7. Maroon and warm green. 8. Deep blue and pink. 9. Chocolate and pea-green. 10. Maroon and deep blue. 11. Claret and buff. 12. Black and warm green."

(22.) *Influence of Frost on Iron.*—"The following extract from Kirkaldy's work on iron and steel goes far to prove that the effect of cold on the strength of iron is less injurious than is generally imagined:—Frost being considered to act injuriously on the strength of iron, some experiments were made during the severe weather in Dec., 1860, to ascertain its effects. A bar of Glasgow B best, $\frac{3}{4}$ in. diameter, was converted into ten bolts, in the ordinary way; six were exposed all night to intense frost, and tested in the morning with the thermometer at 23 deg. Fahr. The other four were kept in a warm place, and carefully protected during testing. Three were tested with gradual, and seven with sudden strains; it was found that when the strain was gradually applied there was very little difference between the specimen tested in the ordinary condition and the two that were frozen; the former bore 55,717, the latter 54,385; difference, 1,332 lb., or 2·3 per cent. less. The difference under sudden strains is somewhat greater, viz., 3·6 per cent. less when frozen. The load just sufficient to cause rupture was in the one case somewhere between 50,535 and 49,948; in the other, between 49,060 and 48.109; the mean in the one instance being 50,391, in the other 48,584; difference, 1,807 lb., or 3·6 per cent. The writer regrets that other duties prevented him from carrying out his intention of repeating these experiments with bars of various qualities. It will be noticed that the bar tested happened to be of superior quality: had it been of a coarser description, the difference when frozen might have been much greater. The frozen bolts were coated with a thin layer of ice, for the purpose of better observing the effects produced. In specimen, with strain slowly applied, the ice gradually became opaque and white, and just before breaking it resembled hoar frost. In another specimen, under sudden strain the ice remained transparent, and the instantaneous stretching of the specimen was most beautifully exhibited by the ice cracking and forming a series of complete rings. In yet another, the strain was greater than in the last, and caused the rupture of the specimen; the heat thereby generated was apparent by the ice melting, and in the formation of vapour."

(23.) *To Calculate Strength of Wrought-Iron Girders.*—"Our correspondent, Mr. Robinson (p. 192 'Builder'), appears to have quoted Fairbairn in a hurry, and so fell into a mistake. The formula runs:—Multiply the area of the bottom flange, the depth of the web, and constant, 75 or 80, as the case may be, and divide by the distance in inches between the supports. Or:—$W = \frac{a\,d\,c}{l}$, where W is the breaking weight in tons; *a*, area of *bottom* flange; *d*, depth of girder; *c*, constant = 75, for plate girders, or 80 for box girders; *l*, length. All dimensions in inches. The sectional area of the top flange should be to that of the bottom flange, as 12 to 11."—*Builder.*

From same periodical we take the following:—

(24.) *Cast-Iron Columns.*—"Your correspondent, who inquires for a formula for hollow cast-iron columns, will find it given in Mr. Hodgkinson's work on cast-iron, published in 1846, from which all subsequent writers on the subject have quoted. His formula is (p. 334):—

"Strength in tons $= 44{\cdot}3 \times \frac{D^{3\cdot6} - d^{3\cdot6}}{l^{1\cdot7}}$ where D and d are the external and internal diameter in inches, and l is the length of the column in feet. In order to aid in the calculation of this formula tables are there given of values of $d^{3\cdot6}$ up to 12 inches diameter, and of $l^{1\cdot7}$ up to 24 feet length; but the formula is intended to apply to columns of higher dimensions; and in every particular case that may occur it is only necessary to perform a simple logarithmic calculation."

(25.) *Coating Iron with Brass.*—"Iron ornaments, &c., were formerly covered with brass by preparing the surface so as to remove all organic matter which would prevent adhesion, and then plunging them into melted brass. A thin coating is thus spread over the surface, which admits of being highly polished or burnished. The process now usually employed is the electro-magnetic. A solution of brass for the purpose may be prepared by dissolving 8 oz., Troy weight, of cyanide of potassium, 2 oz. of cyanide of copper, and 1 oz. of cyanide of zinc in one gallon of rain or distilled water; then add 2 oz. of muriate of ammonia. The solution is to be used at 160 deg. Fahrenheit for smooth work, and from 90 deg. to 120 deg., with a compound battery of from three to twelve cells."—*Building News.*

(26.) *Case-hardening.*—"Put the articles to be case-hardened, after being finished but not polished, into an iron box in layers with animal carbon, that is horns, hoofs, skins, or leather, partly burned, so as to be capable of being reduced to powder, taking care that every part of the iron is completely surrounded; make the box tight with a lute of sand and clay, in equal parts, put the whole into the fire, and keep it at a light red heat for half an hour to two hours, according to the depth of hardened surface required, then empty the contents of the box into water, care being taken that any articles liable to buckle be put in separately and carefully, end in first. Cast-iron may be case-hardened as follows:—Bring the article to a red heat and roll it in a mixture of powdered prussiate of potash, saltpetre, and salammoniac, in equal parts, then plunge it in a bath containing 2 oz. prussiate of potash, and 4 oz. salammoniac per gallon of water."

(27.) *Effects of Vibration on Wrought-Iron.*—"We (the *Mechanics' Magazine*) are inclined to offer a fresh explanation of the deterioration of iron under vibration, and of the partial restoration of its tensile strength by annealing. Each bundle of fibres in a bar of wrought-iron consists of a number of very small crystals. We might compare a piece of good wrought-iron, properly forged or rolled, to an assemblage of strings, each string being composed of a thread of small crystals. An exaggerated picture could be afforded of this by imagining a bundle of glass threads. If the iron has been burnt in the manufacture, instead of these threads being continuous, they are broken in different parts of their length. The same effect is produced after a long-continued jar; there is a solution of continuity in the fibres—they are shaken apart, and the fibres of the iron threads are broken up into shorter pieces. Deflection will produce a similar effect. Frost, or a sudden chill, will contract the fibres, and they will be pulled asunder. On the application of a low red-heat—the process of annealing—the ends of the crystal threads again come into contact through the resulting expansion. The expansion of the whole mass favours the ultimate coherence of the fibres; and, on contracting, the wrought-iron returns to its pristine state—that of a bundle of crystal fibres. Thus, under long-continued vibration—before it receives its *coup de grace*—it is already partly broken; its intimate structure, inaccessible to the eye or to atmospheric influences, is already partially in fragments. The application of a *gradual* strain to iron thus deteriorated and brittle, would have the effect of drawing out the fibres that were still entire, leaving undisturbed the parts that had already given way in the interior. According to this, it will be evident that the face of the fracture—at a right angle to the axis—of a bar of iron injured by vibration, would show no signs of injury; but if it were possible to examine the structure in a like line parallel to the axis of the bar, it would, perhaps, be seen that the fibre was broken up into pieces of different lengths."

(28.) *The Elastic Limit of Wrought-Iron.*—"It is probable that no body is completely inelastic, just as no body is perfectly elastic. The necessarily intimate connection between the breaking strain and elastic power of materials used in construction has long been foreseen, but, strange to say, we are even now in want of sufficient experimental data on this subject. In the absence of experiment people have contented themselves, as is usual, with theorising. Amongst scientific castles in the air may be reckoned the three principles we find enunciated in Tredgold's "Practical Treatise on the Strength of Cast-Iron." "The first is, that the strength of a bar or rod to resist a given strain, when drawn in the direction of its length, is directly proportional to the area of its cross section, while its elastic power remains perfect, and the direction of the force coincides with the axis. The second is, that the extension of a bar or rod, by a force acting in the direction of its length, is directly proportional to the straining force, when the area of the section is the same, while the strain does not exceed the elastic power (or limit of elasticity). The third is, that while the force is within the elastic power of the material, bodies resist extension and compression with equal force." These propositions evidently show an insight into the importance of elasticity in structural materials, but they are all unfortunately based on wrong premises. Mr. Fairbairn, Mr. E. Clark, and others, have shown that the elastic power is affected—that sometimes a permanent set is caused—by a very slight strain, even less than one-third of the ultimate strength or breaking weight of the specimen. The second law is evidently the most absurd, as it assumes that the area of section will remain unaltered under strain—a condition only possible in the absence of all elasticity. The third law is perfectly useless, even if it be true; as, if we had to strictly confine ourselves to the application of forces "within the elastic power of the material," there would be an end to all construction. A late work, giving the results of several hundred experiments, has greatly added to our knowledge of the breaking weight of iron. It is to be regretted that more attention was not given to its elastic limit. Mr. Kirkaldy ascertained the extreme elongation of each of his specimens, the amount of strain producing a perceptible difference in the length of each specimen, and also the progressive rate of increase. It is noticeable that he did not find any diminution of the amount of the breaking strain to result from the additional time employed in testing those specimens in which he noted the progressive rate of increase in length with the increase in weight, but then this time was itself short. The results as to the elongation ascertained were very remarkable, from their apparently capricious variableness, as specimens from even the same brand showed considerable differences. Most of the specimens were found to stretch uniformly throughout their lengths. He ascertained this by dividing the bolts into half-inch spaces, by means of centre punch marks. Plate specimens were polished on one side, and marked with a series of circles, which gradually lengthened into ellipses. But few exceptions occurred in which the increase was not found to be uniform throughout their length. He states, in his general conclusions, that "specimens were generally found to stretch equally throughout their length until close upon rupture, when they more or less suddenly drew out, usually at one part only, sometimes at two, and, in a few exceptional cases, at three different places."—*Mechanics' Magazine.*

PRACTICAL NOTES AND MEMORANDA.—MISCELLANEOUS.

(1.) "*School Stoves.*—A correspondent of the *Dumfries Courier* calls attention to a brick stove for equably and economically heating a school-room or country church or mansion. It is the same in material and principle as a German stove. Being constructed of brick, and no iron required excepting for the furnace bars and doors, it is not expensive. For a good-sized school-room the dimensions may be about as follows:—Length, 4 feet 8 inches; breadth, 3 feet 8 inches; height, 3 feet 8 inches. The principle of it is by sending the flame and hot air from the furnace through a continuation of small flues to arrest the heat before it escapes by the chimney; and, being so arrested and detained in the brickwork, it is given off gradually to the air that comes in contact with the heated material, and continues to be given off long after the fuel is consumed. There are three flues in the length of it, the first crossing, the second recrossing, the third crossing again. The flue current then ascends to an upper set of flues of similar construction; and by repeating a similar course of crossings, terminates in the sixth flue, which is above the first, and from which sixth one it escapes into the chimney by an opening in the brickwork by which the fireplace is built up. The stove stands clear of the wall, also of the floor, being set on brick feet; and there are, as far as can be, vertical vacant spaces between the three double sets of flues in order to admit the air as much as possible to contact with the heated brick. The side walls are built of common fire-bricks; the tops and bottoms of the flues of fire-brick flags. The whole cost for the above size, he says, may be from £6 to £8."

(2.) *Amount of Air required for Ventilation.*—"If it be correct that, when respiration is performed naturally, there are about 18 respirations in one minute, 1,080 in the hour, and 25,920 in the 24 hours, and that by each respiration a pint of air is sent into the lungs—that is, 18 pints in a minute, or in the hour more than two hogsheads, and in the 24 hours more than 57 hogsheads—the effect impurity may produce is evident. When the body is in a state of health there will be 72 pulsations of the heart in a minute. Every pulsation sends to the heart two ounces of blood. Thus 144 ounces are sent for purification to the lungs every minute. In one hour there are sent 450 pints; in 24 hours, nearly 11,000 pints. The blood performs a complete circuit in the system in 110 seconds. These figures show how great is the need for the air we breathe to be pure and wholesome."

(3.) *Ventilation of Apartments.*—"The Academy of Sciences, Paris, has received an interesting paper by General Morin, on the ventilation produced in apartments by fireplaces. The room of the director of the Conservatoire des Arts et Metiers was chosen by him for his experiments. This room may be heated at pleasure, either by a fire in the fireplace, or by a mouth of the calorifere of the establishment. Experiments were first instituted to ascertain the volume of air evacuated by the fireplace by the mere action of the difference of temperature of the outer and inner atmosphere. This natural ventilation was found to be on an average 400 cubic metres of air per hour, when the outer temperature was between 1·8 and 10 deg. centigrade (35·3 and 50 Fahr.), and the inner temperature was between 18 and 22 deg. centigrade (64·4 and 71·6 Fahr.). Hence this room is sufficiently ventilated by the mere aspiration of the chimney, even when, instead of one person, it contains, as it sometimes happens, ten or twelve. Direct experiments afterwards showed that the mouth of the calorifere introduced 150 cubic metres of air at 20 deg. centigrade per hour (68 Fahr.), when the temperature of the calorifere was between 70 and 100 deg. centigrade (158 and 212 Fahr.); but when the temperature of the calorifere was 45 deg., it only furnished 123 cubic metres. The quantity of air thus introduced through the interstices of two windows and two doors was found to be 246 cubic metres per hour. The fireplace drew from 1,200 to 1,300 cubic metres of air per hour, the amount of wood consumed being 8·26 kilogrammes per hour. The same quantity of air was drawn when the fire consisted of coal, the quantity burnt being 4 kilogrammes per hour. From these experiments it appears that nearly the whole of the warmth produced by combustibles in an apartment is carried off through the chimney, and the only useful part of it is obtained by radiation."

(4.) *Quantity and Quality of Ventilation.*—"It is a popular fallacy that all the advantages of good and effective ventilation are secured by the free transmission of air through a building or the apartments thereof; but a wide difference in reality exists between the effect which quantity has on quality when properly diffused, and when it is not so. That vitiated or heated air ascends above the pure or colder atmosphere, as oil does on water, is as easily comprehensible a theory as that water finds its level; and yet from this simple fact not being sufficiently borne in mind in the arrangement of buildings, much defective ventilation is prevalent. Our churches, theatres, concert-rooms, and other halls for public assemblies, are mostly built with provision through numerous corridors, opens, &c., for a never-failing supply of cold air, while but comparatively little is secured for the withdrawal of the heat, in the positions to which its nature causes it to tend, and proportionately to the quantity sure to be generated where a crowd is assembled. The consequence to the health of the frequenters is most deleterious, as the vitiated air, vainly seeking vent at the highest level of the apartment, being forcibly pushed up by the heavier element, is cast down to be rebreathed alike by the healthy and the unhealthy into the sources from which it was emitted; and could we but analyze this heterogeneous mixture, what a variety of poisonous ingredients would be found therein! But to bring the subject more 'home,' our dwelling-houses are often built in utter defiance of all sanitary principles, a current of air from the front door meets another from the back, and simultaneously uniting, they rush into the apartments, up the chimneys, up the staircases, and down again. Fireplaces are so planned that, if their contents were sufficient 'to roast an ox,' the perpetual draught of biting air not only prevents the equable diffusion of heat, but the two extremes meeting treacherously affect the physical system of the occupants. The fact of a fireplace being in a bed-room is regarded as a guarantee of perfect ventilation, but this too is a mistaken notion; for, if placed diametrically opposite the door, the air rushes to the flue with such rapidity as only to create a current from side to side without in any way serving to expel the vitiated air generated by a sleeper. The same forgetfulness of that 'simple fact' also induces the opening of the lower sash of a window when an apartment becomes heated, but the consequence is, that though a volume of fresh air certainly will rush in, still the foul remains playing upwards; and the temperature at the feet becomes suddenly changed to cold, while that at and above the head is still warm. How, under such circumstances, can sufferers from severe colds, bronchitis, &c., &c., wonder whence they originated? The average amount of the oxygenic essential (for each individual) is 600 cubic feet, but for the better preservation of health this must be constantly changing, not in quantity, not by the production of currents and draughts, but by maintaining the quality, which can only be effected by perpetual supply of fresh, and a perpetual expulsion of the foul."—*Dublin Builder.*

(5.) *Improved Crab.*—"After the meeting of the Institution of Civil Engineers on February 1st, Mr. Denison, Q.C., exhibited a small crab, or winch, capable of lifting half a ton with a single pulley, although light enough to be carried in one hand. It had two short barrels with five grooves in them for the rope, and a wheel at the end of each barrel, both of which were driven by equal pinions on the winding arbor. The rope passed from one barrel to the other; and the loose end was either pulled off by nand, or fell by its own weight, or by the weight of the descending blocks or empty bucket attached to it, if the crab was worked alternately, like buckets in a well.

"Several members stated that the machine was a very good one, but that it had been invented long ago, and was now in use in many factories. To this it was replied, that it was surprising that so valuable an improvement of such a clumsy machine as the common long-barrelled crab, should have been unknown to the various engineers, builders, and other persons conversant with such matters, to whom it had been shown or described. It was found that the time spent in fleeting the chain was a quarter of the time spent in actually lifting the Westminster bell to the top of the tower, and two crabs were used for it; whereas, with one such machine as this, it could have been lifted the whole 201 feet without any interruption. The object in bringing the machine to the institution was to make it generally known, and to show its convenience, and it was hoped that the present conversation would assist in doing so, as it probably would, even more completely than if the invention had been really new and comparatively untried."—*Builder.*

(6.) *Modern Houses.*—"The thoughtless purchasers of many of the modern run-up buildings would do well to view and examine them while in the course of erection; if they were only wise enough to do so, their children and descendants would not have reason to lament the period their parents parted with solid gold for airy fabrics which scarcely resist a puff of wind, but are nevertheless saddled with strict repairing covenants and heavy ground-rents. Let buyers ascertain the following, and they will not become the dupes of speculative builders and ground landlords:—

1st. That the foundations are concrete, on solid not made ground.

2d. That all the materials are new and sound.

3d. That the drainage is separate.

4th. That gutters, &c., are lead.

5th. That the dimensions and size of joists, sleepers, lintels, rafters, floor boards, quarterings be had in writing, and no refusal taken. (It is frightful to view the slightness of timber now usually palmed off.)

6th. That each chimney arch is supported by an iron bar.

7th. That the mortar is sand and lime.

8th. What character the estate bears, whether one where, to create ground-rents, the most dangerous structures are run up by builders of no standing and small means, or one where only first-class work and materials are allowed.

The subject has become serious and important.

Trusting you will kindly publish this communication.—I am, &c.,

F. E. Whitmore, Surveyor, in *Building News.*

(7.) Mr. Trueman in the same paper has the following:—

"First—That the house is not built on made soil where the gravel has been dug out and sold.

Second—That it has concrete foundations of proper depth.

Third—That all the materials are new, and the bricks not place.

Fourth—That no iron chimney bars supporting the arch are absent.

Fifth—That the drainage is distinct and separate, properly connected with the main sewer.

Sixth—The strength of joists, quarterings, lintels, sleepers, thickness of doors, floorboards, panelling—in short, quality and quantity of timber used. It is frightful to see how slight houses are now timbered.

Seventh—Whether the grates, locks, ironmongery, and other fittings are of the very cheapest description, unfit for wear.

Eighth—That it has a trap door fire-escape to roof.

Ninth—Avoid zinc gutters, cisterns, flats, &c., as zinc is a very temporary affair. Insist upon lead or stone cisterns, &c.

Tenth—Find out if it is an estate where any scamping is allowed to create heavy ground-rents.

Eleventh—Investigate the title thoroughly; see that it is good.

Lastly—Insist upon a warranty (legally drawn up and stamped) with full specifications attached, subject to penalties if false."

(8.) *French and English Nails.*—"Those who know what French nails are—sharp-pointed cylinders—know that they are very far better than the pyramidal English nails. The French nails want no bradawl to make a hole for them: they are more easily driven in than English nails; and, when in, they hold much more firmly, and never start. When will our English nail-makers get rid of their present absurd form and take to a good one? How long are they willing to let French carpenters have a great advantage over English carpenters? Why do not our carpenters insist on having nails of the best form? Pray drive this into their heads."—N. R. in *Builder.*

(9.) *Fresh air Fire Lump Stove Grate.*—"It is formed of the purest and best fire clay, moulded in suitable forms, adapted to the various arrangements that are found necessary, and consists of the open fire-grate bars in front, surrounded at the sides and back by the fire clay lumps, around which lumps an air chamber is formed, communicating with the external atmosphere, admitting air to a cavity in the lower part of the grate, which communicates with the mouths of the vertical channels in the earthen lumps that surround the fire. The warmth which is communicated to the air through the body of these lumps, and which, from their small conducting power, rarely exceeds 90 degs., and can never be excessive, causes it to ascend through openings in the upper part of the casing, into the apartment, its place being supplied by fresh accessions of air from below. The warm air thus admitted into the apartment is said to float above, and to gradually descend as it cools, its place being supplied by warmer air from the stove grate, and taking with it to the fire all the impure products of respiration, which is carried away by the flue, in which the heat maintains a constant upward current, valves are provided for regulating the quantity and temperature of the fresh air admitted, and its distribution into the apartment when warmed."

(10.) *The Protection of Buildings from Lightning.*—"Pieces of glass were attached to the more prominent points of Christ Church, Doncaster, in consequence of an idea, which is too prevalent, that their non-conducting properties would *divert* the lightning. A single flash laid the costly structure in ruins. On the other hand, buildings have suffered severely even when a conductor was used. One of the causes is, that in many cases comparatively thin *wires* are used instead of very thick ones or *rods.* If a conductor is not sufficiently thick, it will be fused just as a thin wire will be fused by a voltaic current which cannot sensibly raise the temperature of a thick one. * * * * * Another frequent cause of injury results from the fact that a conductor, made even on the most approved principles, is often regarded as affording absolute protection in *itself.* Apart even from the proof afforded by experience, a little attention to the phenomena of the thunder-storm would prove the fallaciousness of the idea. The spire of a church may be protected by a rod; but if, as is frequently the case, there are subordinate prominent points on the building, surmounted by gilt ornaments, not in metallic connexion with the ground; and here and there detached pieces of lead or of zinc; *absolute* protection will not be afforded, from the simple fact that a flash not unfrequently 'bifurcates,' or divides into two portions—one striking the rod, and the other striking some detached object. If the detached object is not in metallic connexion with the earth, it will probably be rent or displaced; and if the flash meets with obstructions in the shape of other non-conductors, it will commit the havoc which we so frequently hear of.

"One writer has shown that the Temple of Solomon was lightning-proof, from the manner in which the metal employed externally was disposed. In the same way, most of our buildings are unintentionally provided with a kind of protector in the shape of the lead or the zinc sheathing and the metallic gutters on the roofs, connected with the rain-pipes, which terminate in the cesspools and drains. Why are those materials not always employed in conjunction with the conductor? Under certain conditions, they offer facilities for the escape of the fluid, which, if taken full advantage of, would in some cases greatly lessen the risk of danger; in most, render edifices lightning-proof. So far as houses are concerned, the desired object may be attained by simple means. Care should be taken that the whole sheating on the roofs should be *metallically* united by nailing the different portions at their points of contact; and every *detached* piece of metal should be brought into connexion by means of a broad strap of copper, of lead, or of zinc. The whole should then be *metallically* united with the gutters which lead into the rain-pipe. Should a flash strike *any portion* of the sheathing, it will thus find a free passage into the ground, provided always that the rain-pipe is a metal one. The lightning-rod should be fixed to the sheathing at a distance of about 2 feet from the chimney-pots. Carbon is one of the best of non-metallic conductors; hence the reason why the soot of chimneys offers peculiar facilities for the passage of the fluid, and thus endangers both life and property.

"The remarks which we have made in reference to the sheathing of houses are also applicable to lofty public-buildings. In addition to their connexion with the rain-pipe, the sheathing and gutters should be united to the lightning-rod by two or three thick wires. Gilt ornaments and vanes surmounting isolated subordinate turrets, &c., should also be metallically united with the rod and the rain-pipe. In every case, indeed, the simple principle should be adhered to of making all the metal employed externally, whether usefully or ornamentally, practically *one conducting body* in good connection with the ground. Twisted strands of copper, or of galvanized iron wire, are well adapted, on account of their flexibility, to the establishment of connection between isolated portions of a building, and they may be easily disposed so as to prevent the marring of architectural features. Where rods are used, the risk of "bifurcation" will be greatly lessened by splitting them for a foot or so from the top, or by attaching two or three spikes obliquely, so as to present several points of attraction. Should danger be apprehended from a *lateral* stroke, we would suggest that spires and elevated monuments be girt *spirally* with a twisted copper or galvanized iron wire-rope—say of seven strands at least—protruding spikes being placed at an interval of every two or three feet. We are not aware whether any arrangement of this kind has been proposed hitherto; but we feel assured that, were it carried out, it would form a highly efficient conductor—more efficient, perhaps, in some respects, than any which we have seen.

"Experience has shown that wherever a system of protection, based on sound principles, has been adopted, no injury has resulted. But experience has also shown that where there is no system, or where only a partial one has been resorted to, the destruction of the most stately edifices may be the work of a moment."—*Scotsman.*

(11.) *Ventilation in Cottages.*—From a contemporary Journal we take the two following articles:—"The discussion on cottage buildings at the Society of Arts, reported in your pages, shows how little progress has been made. There are but few parts of England in which the labourer can pay more than 2s. per week rent; many in which he cannot afford so much. At that rent a cottage, with its ground, fencing, draining, &c., ought not to cost more than £80. For such a sum it is useless to attempt to get more than improvements in some essentials. Nothing can be afforded for ornament, nor is it possible to give any but small rooms. The walls must be thinner than could be wished, and they must be of the material that is cheapest in the district.

"No attainable size of rooms can be healthy without ventilation, therefore every room should have a chimney shaft. The Barrack Commissioners state as the condition of a healthy room, that the occupants should have 20 cubic feet of air per person per minute. At this rate a room, 10 feet square and 8 feet high, contains only enough for one person for forty minutes. As the rooms of a labourer's cottage must for cheapness be small, an attempt should be made to ventilate them properly; a ventilated small bed-room is without question more healthy than an unventilated large one.

"Every cottage should have two small bed-rooms for the children, in addition to the parents' bed-room. If these are all placed on the upper floor, and each has a fire-place—not a grate—in it, while the living-room, on the ground floor, has its fire-place and grate in the middle of the cottage, very little contrivance is necessary to make the sides of the living-room smoke-flue in contact with the flues of all the bed-rooms. As the living-room has a fire in it, more or less time, during every day, the air in the adjoining flues will be warmed, and an upward current will be set up in them. Fresh-air flues should be formed in the chimney jambs by building them hollow, and these should be supplied by a duct from a suitable source outside or above the building. Such a construction is attainable at little cost in a cottage of two floors. The fresh air should be distributed at the top of the rooms, and may be so done as to be insensible as a draught. The cost need not exceed a few shillings.

"Chimneys in the middle of a cottage are economical of heat, and perhaps give increased stability to the structure.

"It should be remembered that when bed-rooms are sufficiently large to admit of all the children being put into one room, the second room is frequently let to a lodger."—Francis Lloyd.

(12.) *Ventilation of Houses.*—"The following notes were prepared by me previously to the discussion at the Institute, on the subject of 'Ventilation,' intending to take part therein; as, however, the opportunity did not occur, and since the meeting has been adjourned, I beg to forward them to you to notice (if you should think them of sufficient interest), prior to the resumption of the discussion.

"Attention to a few very simple rules would do much to achieve the result so devoutly to be wished, viz., the proper ventilation of our dwellings.

"Every window should be proportioned to the size of the room, and, if possible, be opposite a second window; but the last is rarely attainable in ordinary dwelling-houses, and might not be desirable if it were, on other grounds. All windows should rise to within a foot of the ceiling, and be made to open at the top and at the bottom, so that by opening the doors and windows the room may be flushed with fresh air, and in a few minutes rendered perfectly sweet; and even if the doors are closed, the opening of both upper and lower sashes will produce an inward and an outward draught. But windows should not be alone depended upon, since they can only occasionally be employed, when the room is unoccupied.

"External fresh air should be admitted by a tube to a chamber behind the stove, where it may be warmed before entering the room, to feed the fire and the occupants with fresh air, without drawing the atmosphere in draughts through the cracks of the doors and windows, the draughts from which are increased in proportion to the absence of other means of replacing the air exhausted in respiration and the combustion of fuel, &c. The outlet from this air-chamber may be through ornamental fretwork in the stove front. In winter, or at night, and especially if there are gas lights, it will be specially important to provide a ready means of releasing the impure air, without necessitating its being drawn down to the low level of the fireplace, to escape by the chimney-shaft when the windows are closed. For this purpose the chimney-flues should be constructed in duplicate, that is to say, each room should have two flues 9 inches square, each divided by a thin plate of iron only instead of the usual half-brick withe (similar to those invented by Mr. Boyd); one of these flues will be for the smoke, the other for vitiated air. The opening into the latter from the room should be of the same area as the flue itself, and be situate immediately below the cornice of the room near the ceiling, and provided with a means of opening and closing. (Dr. Arnott's valves are the best. The cause of their smoking sometimes arises from the absence of a sufficient quantity of fresh air in the apartment, and also from the wideness of the chimney throat.) The heat of the adjoining flue would cause a sufficient rarefaction of the air to create an upward draught in the flue, and thus the vitiated air would be drawn off from the apartment. To prevent down-draught drawing smoke into the air-flue at the point of exit, the latter should open at the side of the chimney-stack, while the smoke-flue should pass up in the usual manner and escape at the top of the chimney-stack. (The writer has successfully introduced these arrangements in buildings erected by him; and, besides the fresh air supply to the stove, has also admitted air from the hall, through apertures contrived over the head and under the discharging arch of the door.)

"The kind of stoves employed may be those manufactured by Messrs. Boyd, Kennard, and others. And Mr. Billing's throttle valves and terminals will be an advantageous addition, especially in windy weather.

"*Some* cross ventilation by opposite windows should exist in every house, if not in the several rooms, at least in the stairs and landings with which the rooms communicate; so that by opening the room doors a direct current of air may be maintained at pleasure between the windows of the rooms and the stairs. No house can be considered healthy where reservoirs of stagnant air are permitted to exist.

"A false economy commonly incloses the upper stories of staircases between back and front dressing-rooms or closets, so that that portion where the heated and impure air naturally rises is the very part for which no means of ventilation are provided; and should the necessity for light enforce a skylight, it is ten chances to one that any means of opening or closing, or apertures for ventilation, are provided. The trap-door to the roof, if fitted with perforated zinc, might be of some value, but is never so employed, and the roof has no current of air specially provided to assist the escape of such vapours.

"Wherever gas is burning, fresh and foul air-shafts are required, especially in shops, and not only for the sake of ventilation, but for the increase of light by the more abundant supply of oxygen to aid combustion;—in proportion to the purity of the atmosphere is the brilliancy of the light.

"A simple window is insufficient to ventilate a water-closet or lavatory, &c.; and if no cross ventilation can be gained by opposite windows, draught may be secured by external ventilators in direct communication with the closet, or through tubes from perforated zinc-covered openings in ceilings. If this cannot be done, it is better to hang the casement on pivots in the centre than on hinges, the windows being placed as high as possible.

"The soil-drains will also require to be ventilated by external shafts, or they will often ventilate themselves with the dwelling. Every other entrance to the drains to be water-trapped.

"In larger rooms a greater amount of fresh air will be required than can be admitted through the chamber at the back of the fire; and the point chosen for the admission of the fresh air should always be situate opposite a foul-air shaft of equal area, and near the ceiling, or the draught towards the fire will be objected to; and a due proportion should be observed between the admission and dismission of air and the size of the room to be dealt with. Thus, a foul-air shaft, 9 inches by 9 inches, will answer for a room containing 5,000 cubic feet. Where cold air is admitted at the ground it chills the feet, and makes the coldest part of the room cooler, and rarely rises higher than the fire.

"It should be borne in mind that upon the height of the upshaft and the proper influx of fresh air will greatly depend the strength of the draught upward when the air in the shaft is at a low temperature; but if no fresh air is otherwise admitted, the foul-air exit shaft becomes a fresh air admission flue in the absence of fires to warm the adjoining smoke-flues.

"The less horizontal tubing for the conveyance of foul air the better, unless fresh air is admitted at one end and a heated flue receives it at the other. In that case the vitiated air is drawn along by the current as it enters by the perforations beneath the horizontal shaft; but to be of any use they must be very large if of much length. Mr. Kite's ventilators have been successfully used by the writer to produce an upward draught. Mr. Watson's ventilators answer best where no other means of admitting air has been provided. A stable at night, when all doors are closed, is usually well ventilated by one of these, or Mr. Muir's four-point ventilators."—EDWARD C. ROBINS *in professional Journal.*

(13.) *Lessons to be Derived from the Colouring of the Great Exhibition of* 1862.—"After careful consideration," says Mr. Crace, the decorator of the building, "I decided that the general tone of the roof must be light, and that the best colour would be a warm pale grey; that the arched principals must be made to stand out clear from the roof; that they must look well in a perspective of 800 feet; and that they must not look heavy or confused as they approached each other in the distance. No single colour would do, and after a pretty stiff bit of reflection of twenty-four hours, I confirmed myself in my opinion of what would be the most likely way of treating the principals. I have remarked that the form of these is polygonal, and is best explained by the scale drawing marked (A). They are in three thicknesses, the centres of the outer planks covering the joints of the inner ones.

"I considered that the form precluded the use of a continuous repeat ornament, I therefore decided on following the form of the construction, and adopted panellings of blue and red alternately, relieved by coloured lines, intersected at the joints by circles of black, on which are gold stars, and from these spring ornaments in vellum colour with green in the filling, as shown in the coloured drawing.

"Following out this arrangement, I had a pattern painted on paper of the full size of one of the principals, and it was fixed in its place within a week from the time of my appointment; part of that identical pattern is now in this room; it has never been altered, and thus exactly it has been carried out throughout the roofs of the nave and transepts.

"Until the principals were coloured, it seemed to me that the thicknesses were lost; I wished to make the construction evident, and I therefore coloured the two outer edges in cheques of black and vellum colour, and the edge full red. As to the bracings above the polygonal arches I coloured them the warm wood colour, with red or blue coloured lines on the face, and the under thicknesses red.

"I have said that I decided on warm grey for the roof of the nave. I did so because it gave space and lightness; and on its surface I introduced an upright scroll ornament in red, with gold, star-like rosettes, sparingly introduced. My object in this ornament was to raise the apparent pitch of the roof, and to relieve and warm the effect of the grey. The horizontal purlins, on the contrary, I kept purposely light, so as not to depress the rise of the roof, or interfere with, or confuse the effect of the principals. The ridge-piece of the roof, in itself comparatively small, I marked as strongly as possible, as the apex, in black and vellum white, *en cheronne;* on each side I coloured a margin of maroon red, and a little below that a bordering of a very warm green, shaped to accord with the top scrolls of the red vertical ornament, the green being relieved with rosettes of gold colour. At the base of the slope of roof this green is again introduced in much the same way, and the band of maroon also. Below this are the clere-story windows.

"The next important features in the nave are the iron columns, supporting the principals as well as the galleries. These I have painted pale bronze colour, relieved with gold colour vertical lines. The capitals are gilt, the grounds of the ornaments being picked in rich red or blue alternately; the centre blocks of the columns are also coloured red with bands of blue, or *vice versa*, the mouldings being gilt, and the same style of colour is confined to the bases. The top plate above the columns is painted bronze colour, relieved with light gold colour ornament on the upper part, and a Vitruvian scroll in gold colour, with a maroon red base on the lower part.

"The gallery railings are light bronze colour, the rose, shamrock, and thistle ornaments being partly gilt, and the whole backed with deep red cloth. The plate under the gallery is painted oak colour, relieved with deep brown interlaced ornaments.

"I have kept the part below the line of arches purposely quiet in colour, in order that the brilliancy and richness of the various articles exhibited may not be interfered with. The roof, on the contrary, is rather vivid in colour, to carry up, as it were, in some degree, the gaiety of the scene below; and this will be still further sustained by a series of banners of the various countries, whose products are assembled in this International Exhibition.

"Much variety of opinion has been expressed at my introduction of the vivid colours in the arched principals of the nave; but I think that many who fancied it would look too powerful, will confess their surprise at its comparatively quiet effect now that it is completed. The colours being properly balanced have neutralized each other. Most of you probably know that blue, red, and yellow, in the proportion of three, two, and one, when mixed with white, produce a grey exactly the same as the grey produced by mixing black and white. I will show you; I take ultramarine blue three parts, vermillion two parts, and chrome yellow one part. I mix them together, add some white—you observe it is grey. I take some black and white, mix them, and identically the same grey is produced. If you paint on a disc radiated stripes of blue, red, and yellow, in proper proportion, and make the disc revolve rapidly, you find grey produced the same as if they were stripes of black and white. The effect of the roof of the nave exemplifies this theory.

"I have heard it said by some, that it would have been better to have employed panellings of one colour instead of two to each principal, and made the principals alternately blue and red; in my opinion they would have been utterly disappointed; the striped contrasts would have by no means given the softness, richness, and glow of the present colouring. To convince myself, I, at one stage of the colouring, tried, by fixing blue paper over the red panellings in one principal, and red paper over the blue panelings of another, but the effect was not nearly as good, and I was confirmed that the principle I had adopted was the right one.

"You will find this principle of counter-changing colours adopted in most of the decorations of the early masters which abound in Italy. Those decorations, so beautiful, so interesting, rich, glowing in colour, full of fancy and taste in the ornament, the masses well arranged, show the most perfect harmony everywhere, and are dignified by often acting as the frame-work of the highest gems of art. In plan their form is dodecagonal, or twelve-sided, but they are made to assume the appearance of an octagon, because the arches towards the nave and transept cross each other, and form a kind of angular-arched opening of 85 feet span, the intermediate arches being about 35 feet span. From the floor of the nave to the springing of the domes is 117 feet, the total interior height to the crown of the domes being about 200 feet. There are 12 main ribs to each dome, meeting in a sort of ring plate, and thence 8 of them carry on to the centre. The crown of each dome has an ornamental zinc covering, as explained in the drawing; all below this is glass.

"My drawings will best explain to you the colouring I adopted for the top of the domes. The main ribs are painted bright red, with spaced black and white at the edges, and a fine gold line up the centre spreads at intervals of about four feet into lozenges and circles containing gilt stars on a blue ground; where the main ribs reach the ring plate I carry round the red, marking the points of intersection with black and white; thence the eight main ribs are painted deep blue, relieved with red, gold, and black, until they meet in the centre pipe or pendant, which is gilt bordered with red. The shaped covering, or umbrella, as I am accustomed to call it, is painted light blue; gold colour and gilt rays diverge from the centre, and streaming a considerable way down the blue, the shaped outline of which is bordered with red and gold ornament.

"In decorating the walls of the domes, the solid parts between the arches, and the springing of the roof, it was necessary to consider the probable effect of the great mass of light above. On the one hand it was desirable to sustain it with sufficient strength of colour, on the other it would be dangerous to make it too heavy.

"The moulding of the cornice and facia are painted vellum colour, very slightly relieved by gilding; the trusses are gold colour; the facia between them is red, with a vellum patera; the soffit is green. The broad facia below is painted blue, and on it is inscribed in gold letters, three feet high, the exordium of David, in the 29th chapter of the first Book of Chronicles, 'Thine, O Lord, is the greatness, and the glory, and the victory, and the majesty; for all that is in the heaven and the earth is thine;' and 'O Lord, both riches and honour come of thee, and thou reignest over all; and in thine hand is power and might, and in thine hand it is to make great.'

"The large iron columns, which rise nearly 100 feet high, are painted dark maroon colour, their capitals being richly gilt. The panelling between the arches and the frieze is painted in shades of red, relieved by coloured lines; in the four broad compartments are inscribed, on dark-green panels, Europe, Asia, Africa, and America; below, on a circle, are the initials of those so beloved by us all, Victoria and Albert."

(14.) *Some Notes on Safety of Construction.*—"In all buildings a certain degree of *safety* is of course always ensured by attention having been paid to the laws of stability. The strain on a girder floor, or on the iron rods of a suspension bridge, may for example have been amply provided for, under all the imaginable contingencies proper to mere *strength*, or quiescent stability; and yet each of these structures may be destined to undergo some peculiar strain or trial, operating, it is true, on their strength of construction, but in its nature so exceptional, and, as it were, foreign to one's ordinary idea of that quality, as to necessitate (lest it should be lost sight of) a distinct classification. Thus, in the case of the floor, *pressure* or dead weight, as it is termed, may have been carefully provided for by the architect; and yet the floor may fail disastrously by the (*quà* question of *stability*) unexpected conversion of the apartment into a granary, or a warehouse for the stowage of heavy goods. Here, reflecting only on what is due to *strength*, the architect is placed at a cruel disadvantage, by no means unlikely to compromise his professional credit. How much more may he not be entrapped into such a risk, when, not mere excessive *pressure*, but a more formidable element of destruction, *impact or concussion*, is unexpectedly brought to bear on his floor, and the apartment in question becomes changed into a workshop for motive machinery, or is applied to the purpose of a dancing saloon! In the case of the suspension bridge it is highly probable that the contrivers of the bridges at Angers in France, or at Broughton in our own country, had made every provision in these structures for all that was required for the ordinary essential of *strength;* and yet considerations of *safety*, superadded to those of mere strength, might possibly have averted the fatal consequences that ensued, by these two structures being subjected to the operation of simultaneous *concussion*, conveyed in each case by the regulated military tramp of the soldiers, essaying to pass over them in safety. Considerations of *safety* (altogether supplementary to those of stability) might possibly have suggested to the engineer of the suspension bridge at Yarmouth the not impossible circumstance, that actually occurred—the sudden rush of its crowded occupants from one side of the bridge to the other, to see a fool swim by in a washing tub, drawn by geese. Certainly no reasonable calculations, with a view to the mere *strength* of the structure, would have averted the fearful catastrophe that ensued: while some precautions against a recurrence of it do really pertain to considerations of *safety*.

"*Pressure* itself, though a far simpler element of destruction, will not always be adequately provided for by the mere observance of the rules of simple *stability;* and hence the necessity for the architect's keeping before his mind, whilst designing any structure of consequence, the important quality of *safety*. The presence of a dense crowd of people has been often known to bring down the floors of apartments, adequate for all ordinary pressure; and still more frequent cases might be named of the failure, under such conditions, of floors, supported at one end only, such as those of projecting galleries or balconies, and the landings of stone staircases—nay, even the stairs themselves, as we have but recently seen in the case of a public structure in the metropolis.

"Before dismissing the subject of *concussion* or *impact*, just alluded to, mention may be made of the liability of all water-side buildings to its influence. A building constructed on the brink of a lake, with its base well adapted for every likely strain, consequent from still water, may be found wanting should that water become violently agitated by a storm, or by the oft-recurring action of the paddle-wheels of passing steamers. Some curious examples of this might be mentioned. An instance is recorded—one scarce within the architect's province to foresee—of a large building of several stories being thrown to the ground, by the combined action (in the way of *impact*) of air and water, set in motion by the sudden fall of a retaining wall *on the opposite bank of a river*, on which it (the building in question) had been constructed. In its case, certainly, no measures of even *safety* would have obviated such an accident as that; but the mention of it will supply a hint of the insufficiency of the ordinary rules of mere stability to meet some possible test to which a structure may be subjected by even natural causes. It may, moreover, be useful to add that, with regard to the failure of the retaining wall just mentioned, whatever may have been its shortcomings on the score of *stability*, the catastrophe of its fall was in great measure attributed to the *danger* to be always apprehended from the accumulating *pressure* of undrained, pent-up moisture behind it.

"Safety from thieves, or *depredation*, is a very prosaic matter to consider, but it is one that must be thought of in planning a building, and of which the architect is only likely to be reminded by subjecting his design to be tested by the requirements of the quality we are discoursing of. We have not many suggestions to offer on this subject; it will be sufficient to call attention to it. Various schemes, protected by patent, have been offered to architects from time to time, and to these he may be referred. Meantime, he himself may be supposed to be likely to make *some* provision for safety in this respect, if not by the construction of alarm bells or otherwise, at least by seeing that certain windows, and particularly sashed doors, are duly provided with shutters, or with iron gratings, as the case may be. It is a question affecting rather the specification of a building than the plan; and what remains to be done by the architect is to see that that document makes due provision for all suitable night-bolts and other ironmongery.

"We have only to add that, in connection with this question of safety from furtive or surreptitious ingress is the one of *surreptitious egress*, and that, in planning a prison, or any place of detention—such as a lunatic asylum, for example—provision must be made, by such expedients as *ha-ha's* along the boundary walls, contracted ornamental iron casements in the windows, and the like, for preventing, without semblance of intention, the *egress* of the unfortunate inmates. In the case of a prison the means of prevention need not of course be subject to any pretence or concealment, but here much circumspection will be necessary; all corners likely to serve as hiding-places for the prisoners, all weakness in the apertures for light, or horizontal projections in the walls, are to be sedulously avoided; and even the very sewers, or large drains, are to be guarded from *egress* of the prisoners by iron gratings, filling up their sectional area."—*Building News.*

In concluding the matter contained in these supplementary pages, it is scarcely necessary to name specially the sources from which we have derived much of the matter comprising the Notes and Memoranda, these being generally indicated in each case. We trust our readers will agree with us that in the matter we have given under these heads there is comprised not only much valuable information on points of obvious importance, but many practically useful hints and suggestions on others, which, being of minor value, are apt often to be overlooked, but which are nevertheless worthy of the attention of the Architect and Builder. And it is in the frequent giving of these that is constituted not the least useful feature of our leading professional journals, as the "Builder" and the "Building News," and which consequently gives them so high a claim upon the notice of all interested in the progress of the building arts. In the Plates which accompany these pages, we have endeavoured, by a set of drawings specially prepared for our purpose, to illustrate the special characteristics of the various styles adapted to Modern Domestic Structures. The drawings illustrative of Continental Architecture are, in the majority of instances, taken from buildings actually erected abroad, and which are now published for the first time, while in those specially designed the details have, in nearly all, been adapted from sketches taken on the Continent exclusively for the purposes of our work. In Plate G the reader will find some sketches of Continental Construction in figs. 3 to 13. For these we are indebted to the German works of MM. Gustav Linke, Professor of the Technical Institution, and of Carl Matthaey, Architect.

THE END.

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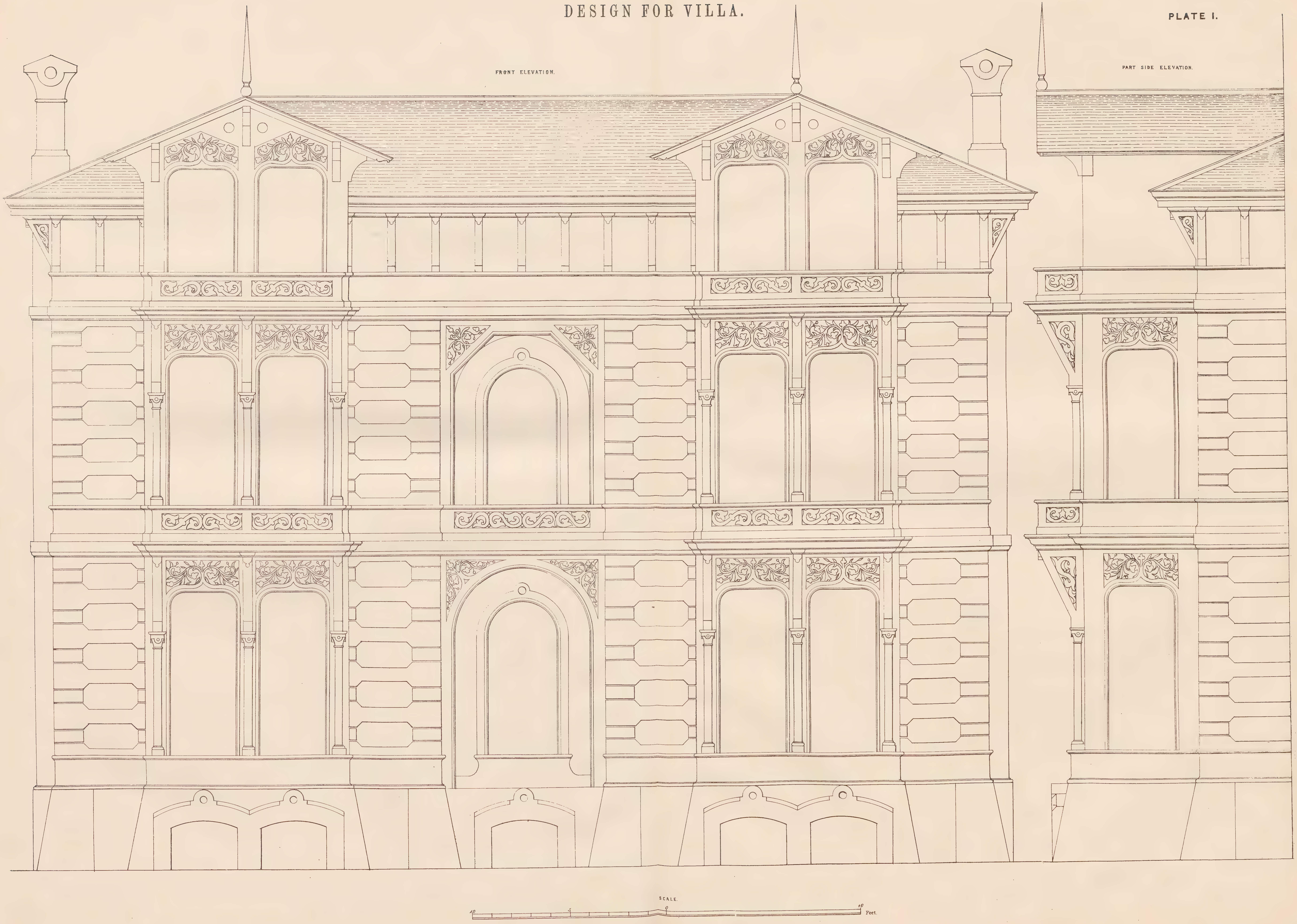
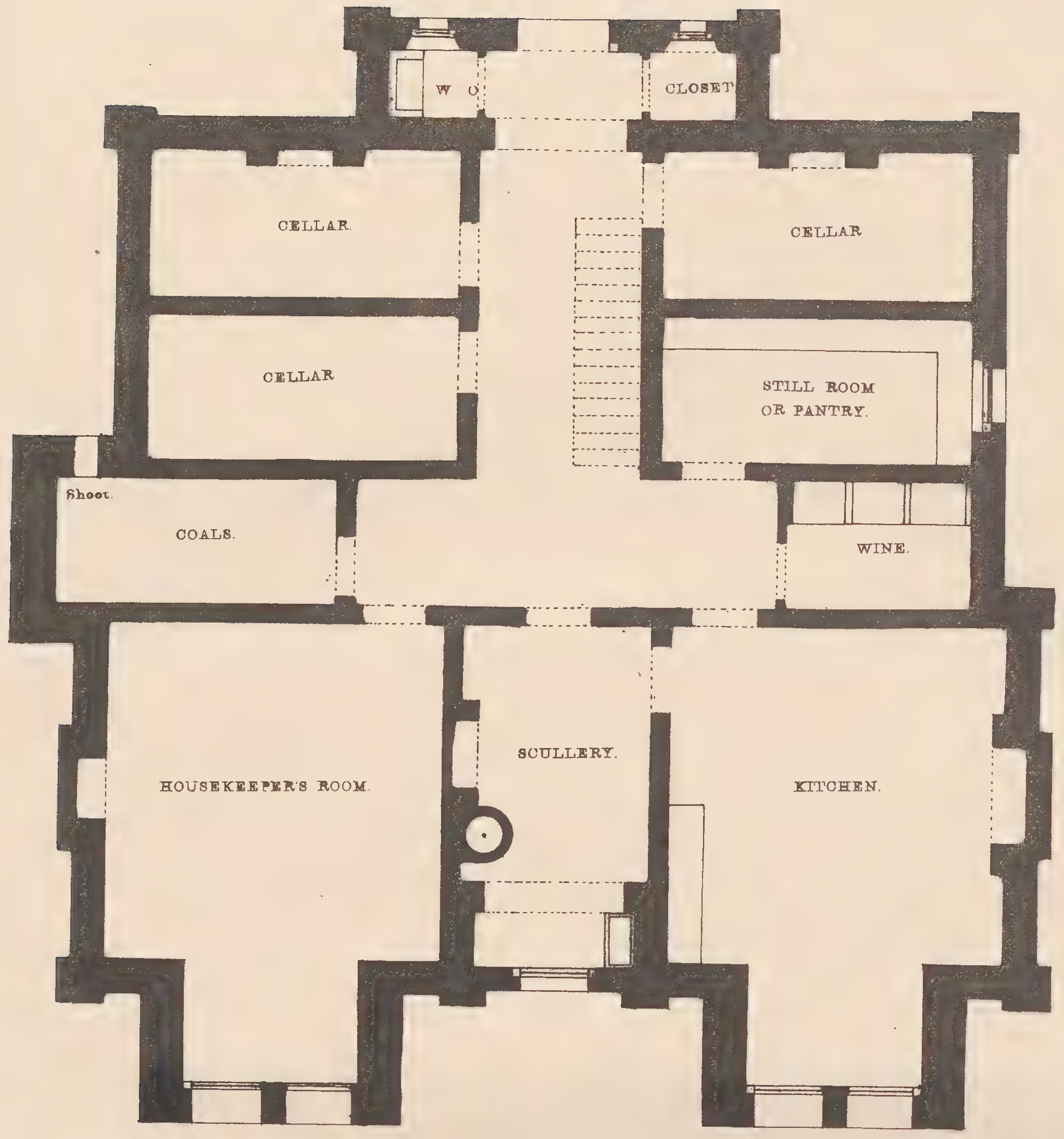
DESIGN FOR VILLA.

PLATE I.

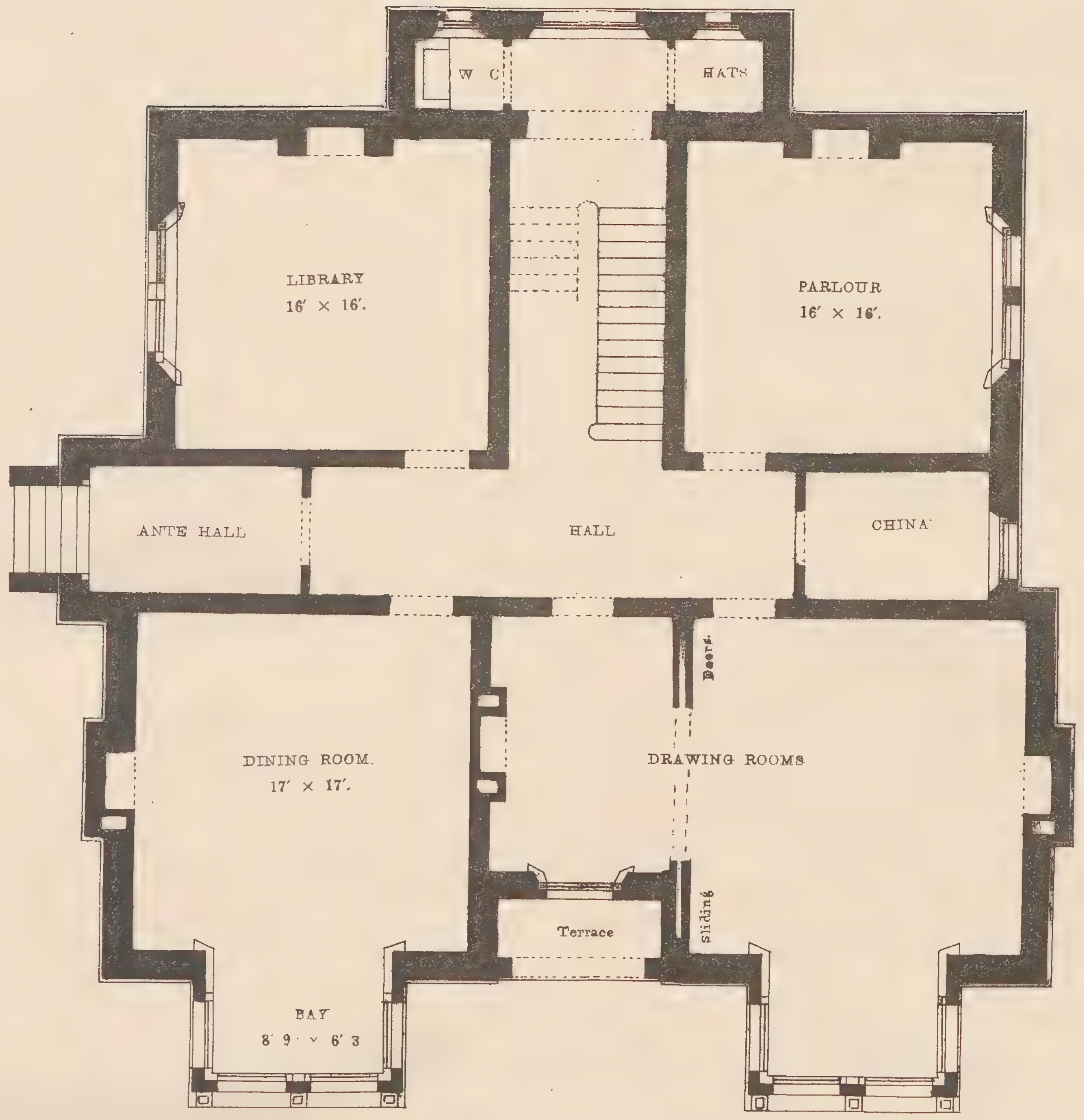

FRONT ELEVATION.
PART SIDE ELEVATION.
SCALE.
10
5
0
10
Feet.

PLANS AND ELEVATIONS OF VILLA IN PLATE I.

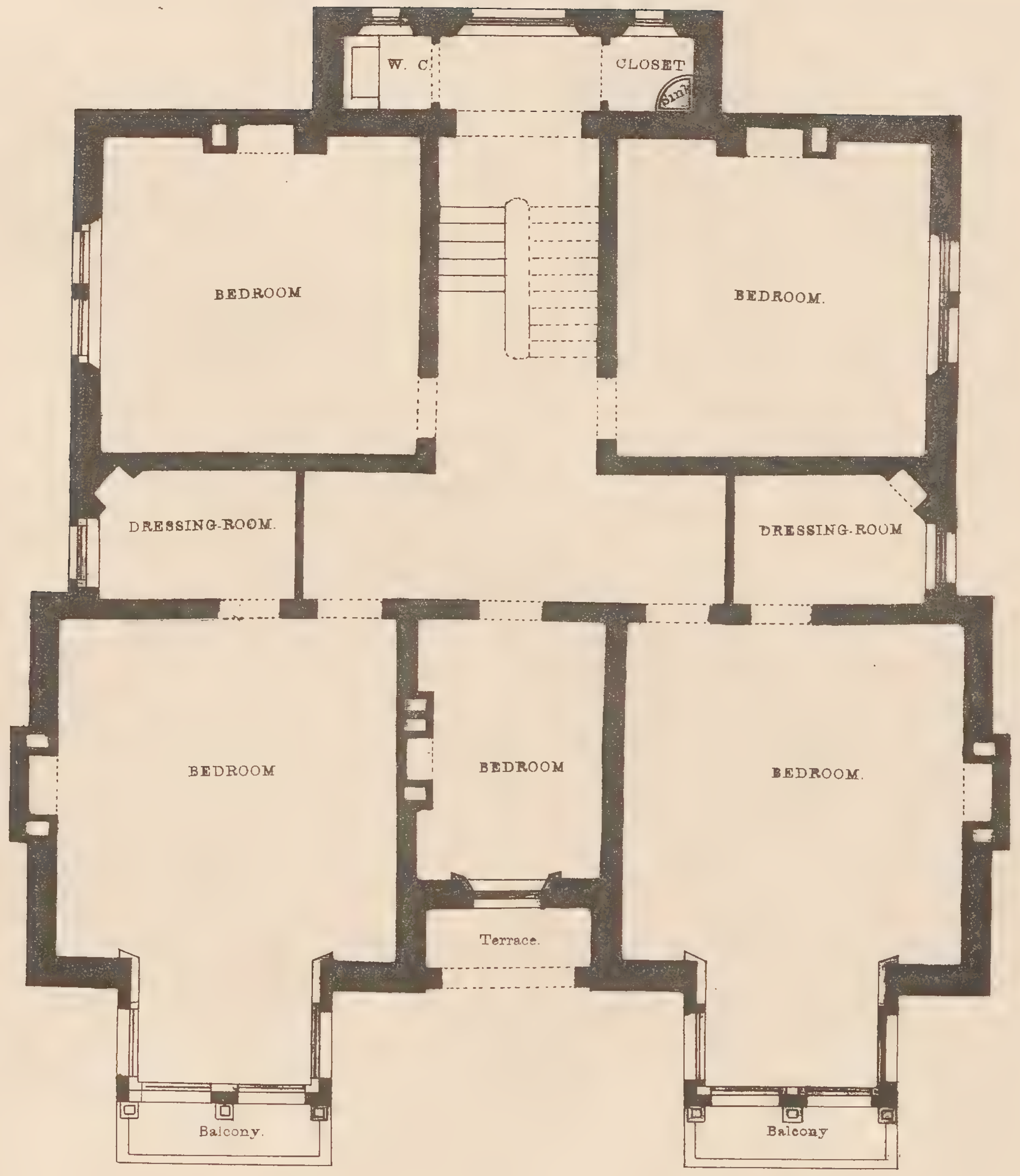
PLATE II.


W.C.
CLOSET
CELLAR
CELLAR
CELLAR
STILL ROOM OR PANTRY
Shoot
COALS
WINE
HOUSEKEEPER'S ROOM
SCULLERY
KITCHEN

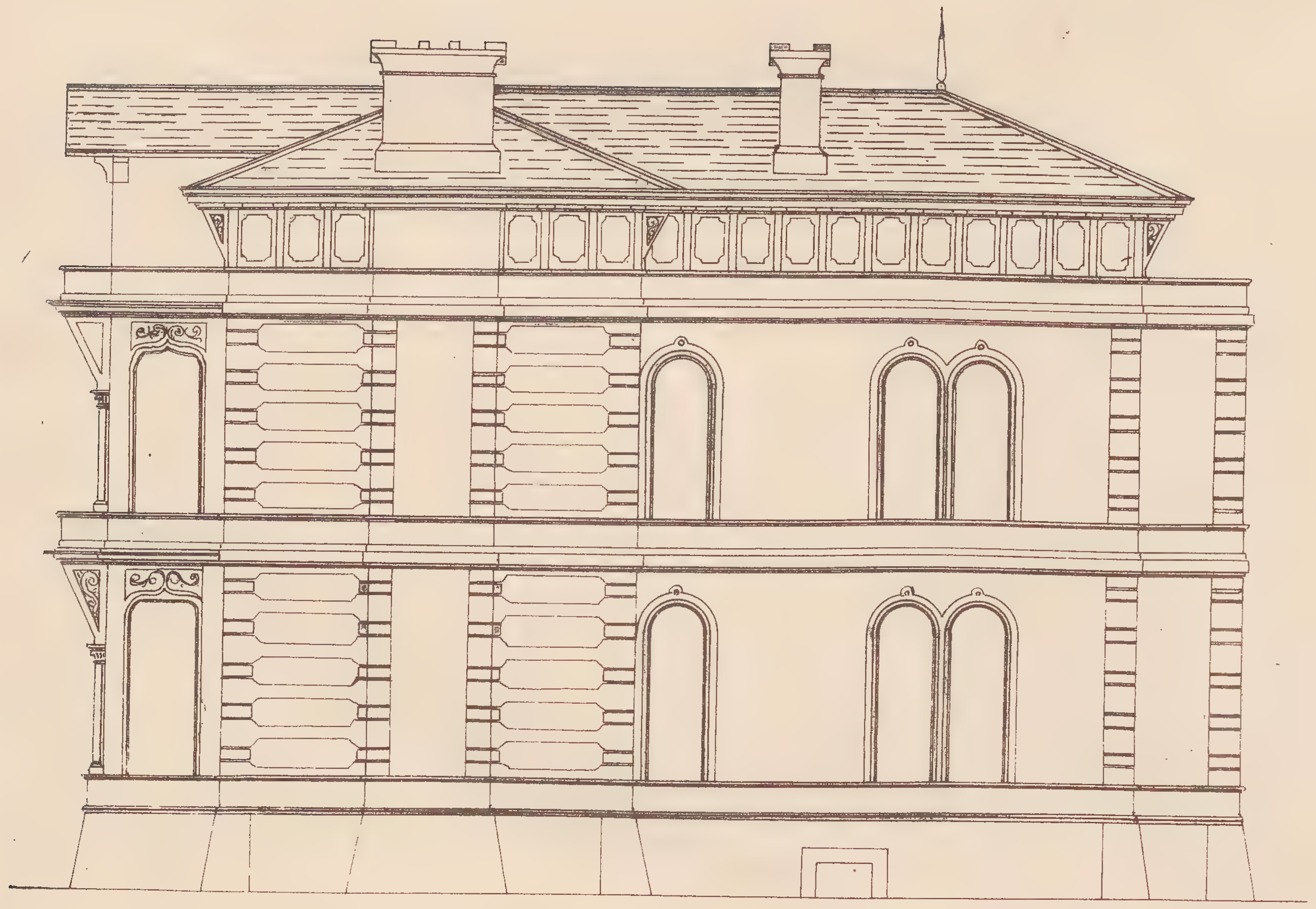
BASEMENT PLAN.


W.C.
HATS
LIBRARY 16' × 16'.
PARLOUR 16' × 16'.
ANTE HALL
HALL
CHINA
DINING ROOM 17' × 17'.
DRAWING ROOMS
Doors
Sliding
Terrace
BAY 8' 9" × 6' 3

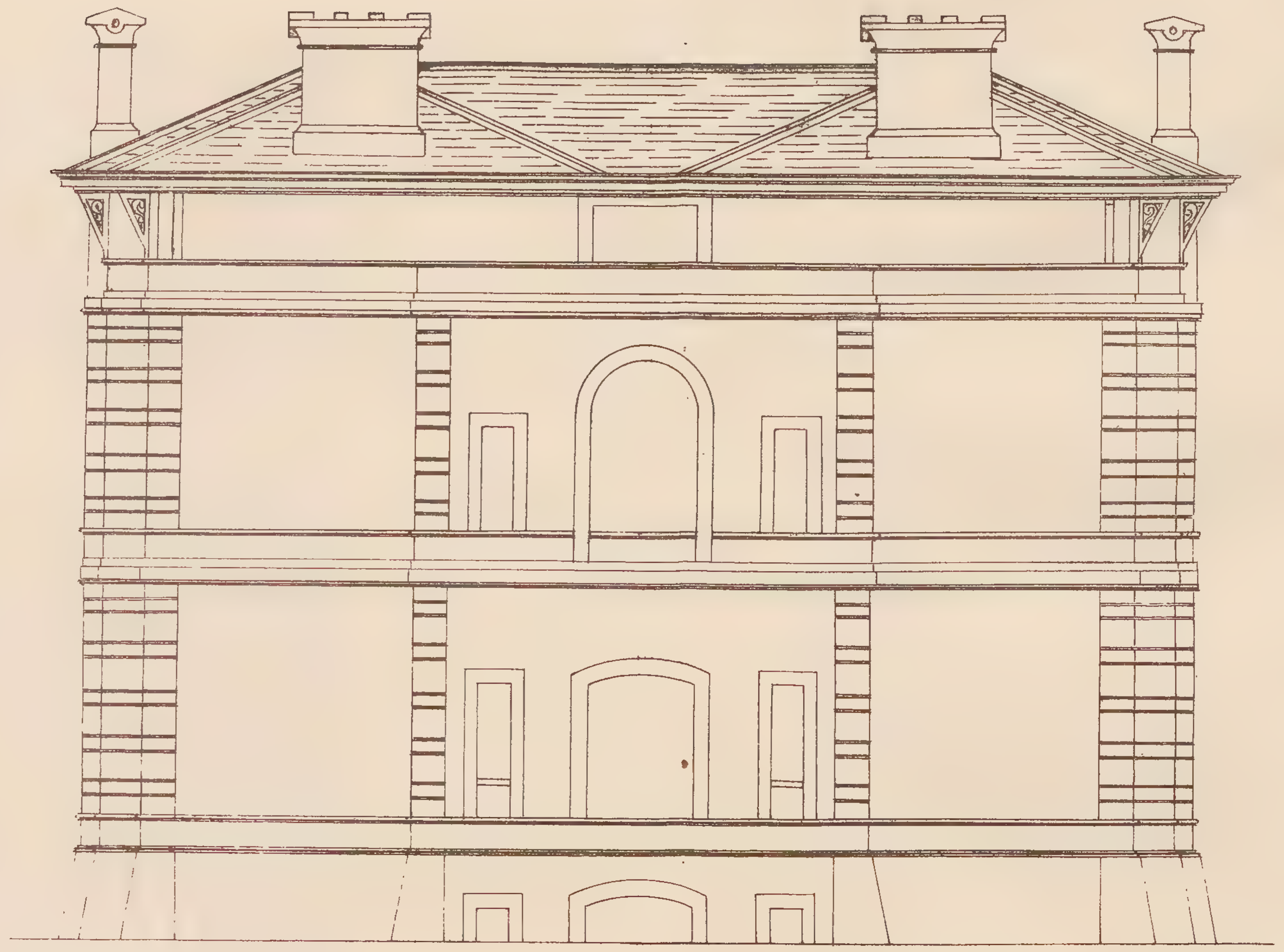
GROUND PLAN.


W.C.
CLOSET
BEDROOM
BEDROOM
DRESSING ROOM
DRESSING ROOM
BEDROOM
BEDROOM
BEDROOM
Terrace
Balcony
Balcony

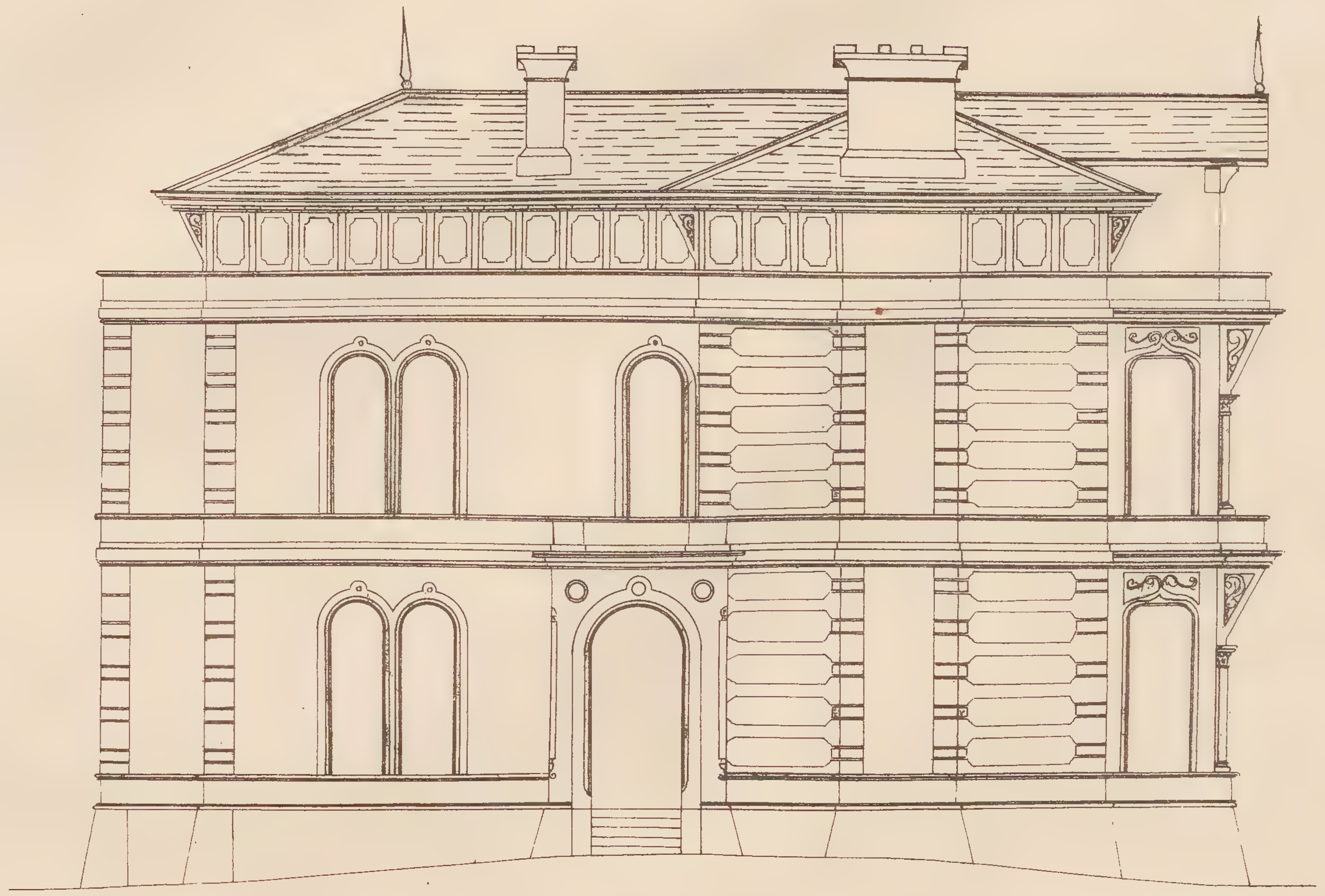
FIRST AND SECOND FLOOR PLAN.



SIDE ELEVATION.



BACK ELEVATION.

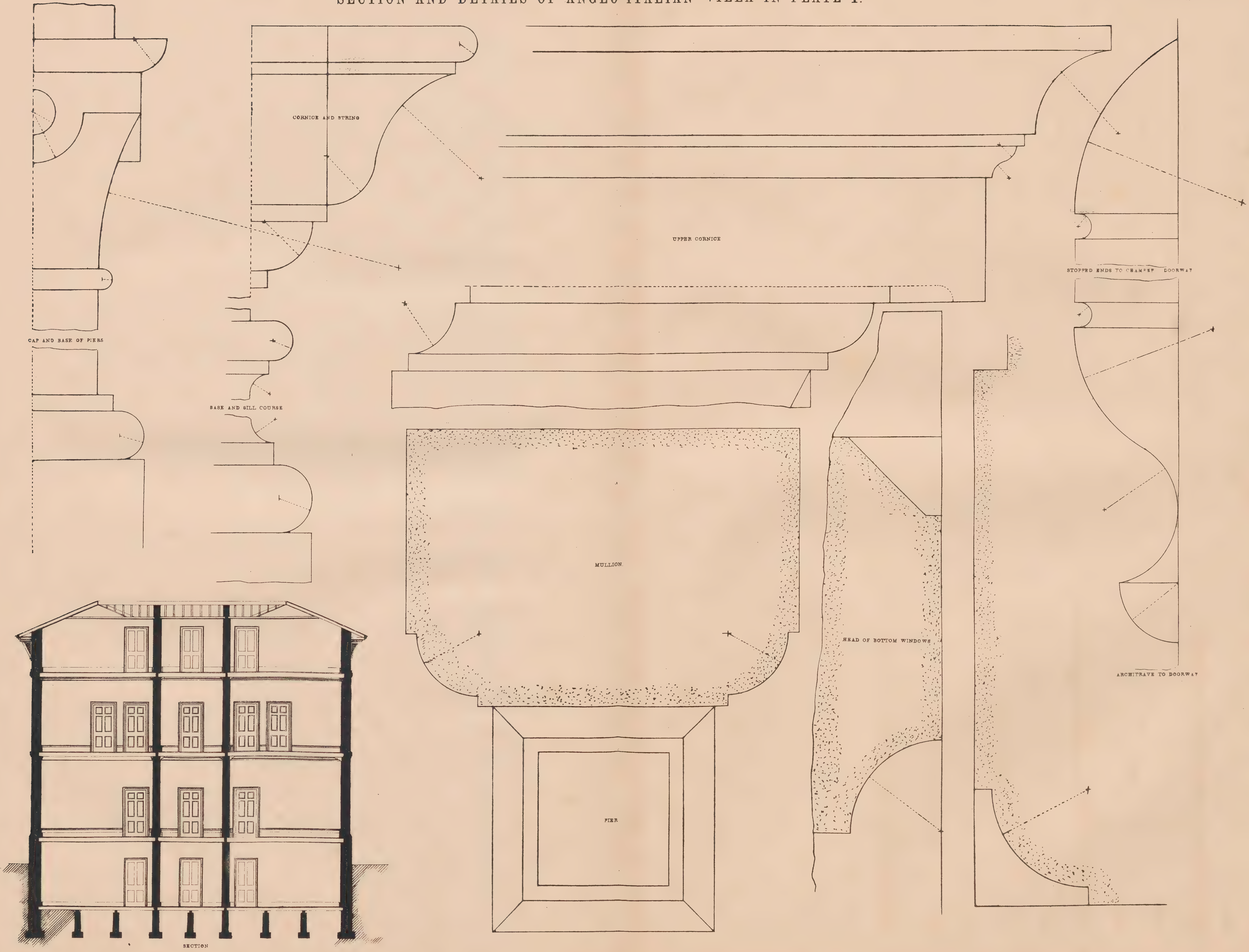


SIDE ELEVATION.

SCALE ONE-EIGHTH OF AN INCH TO ONE FOOT

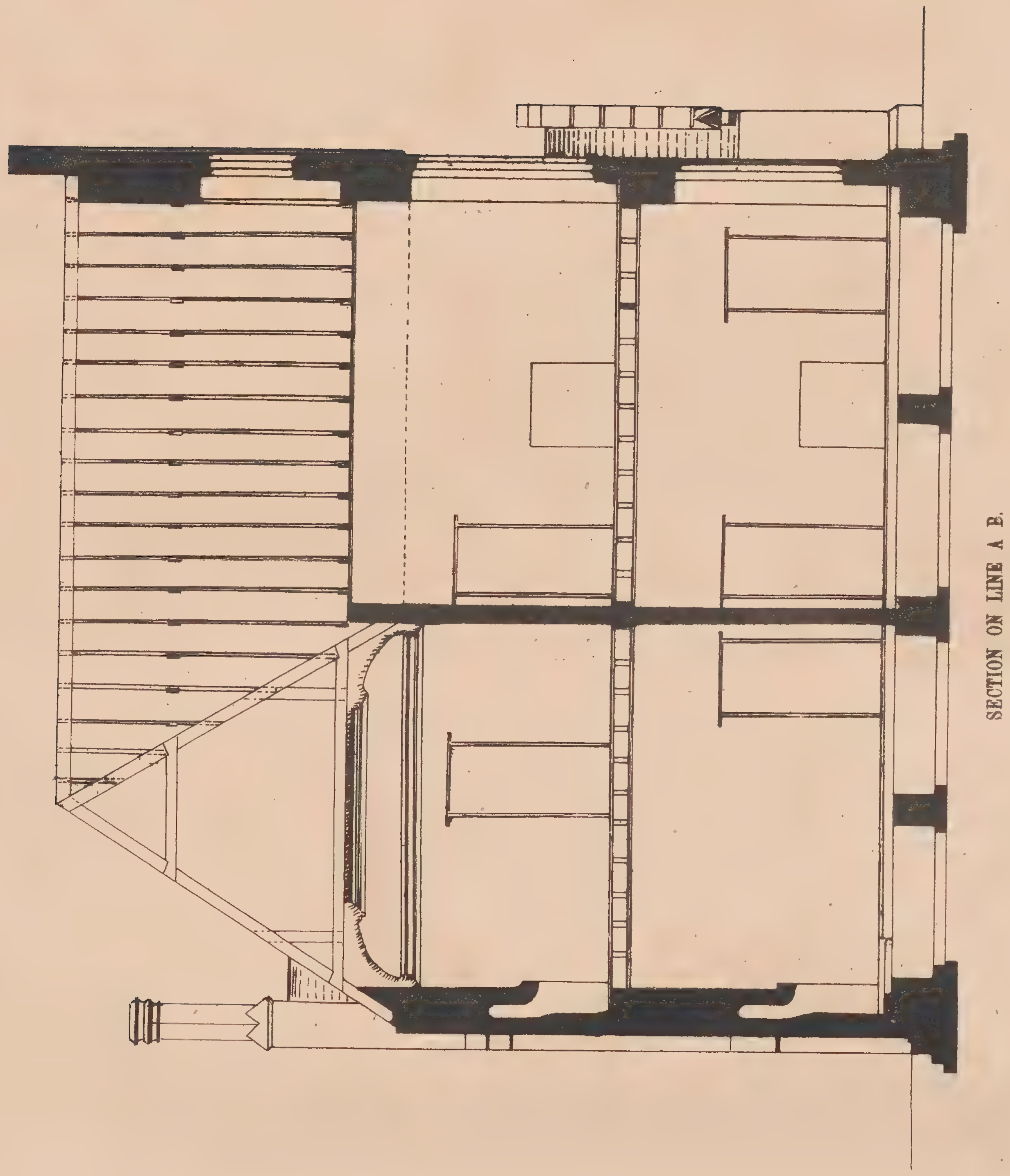
SECTION AND DETAILS OF ANGLO-ITALIAN VILLA IN PLATE I.

PLATE III.

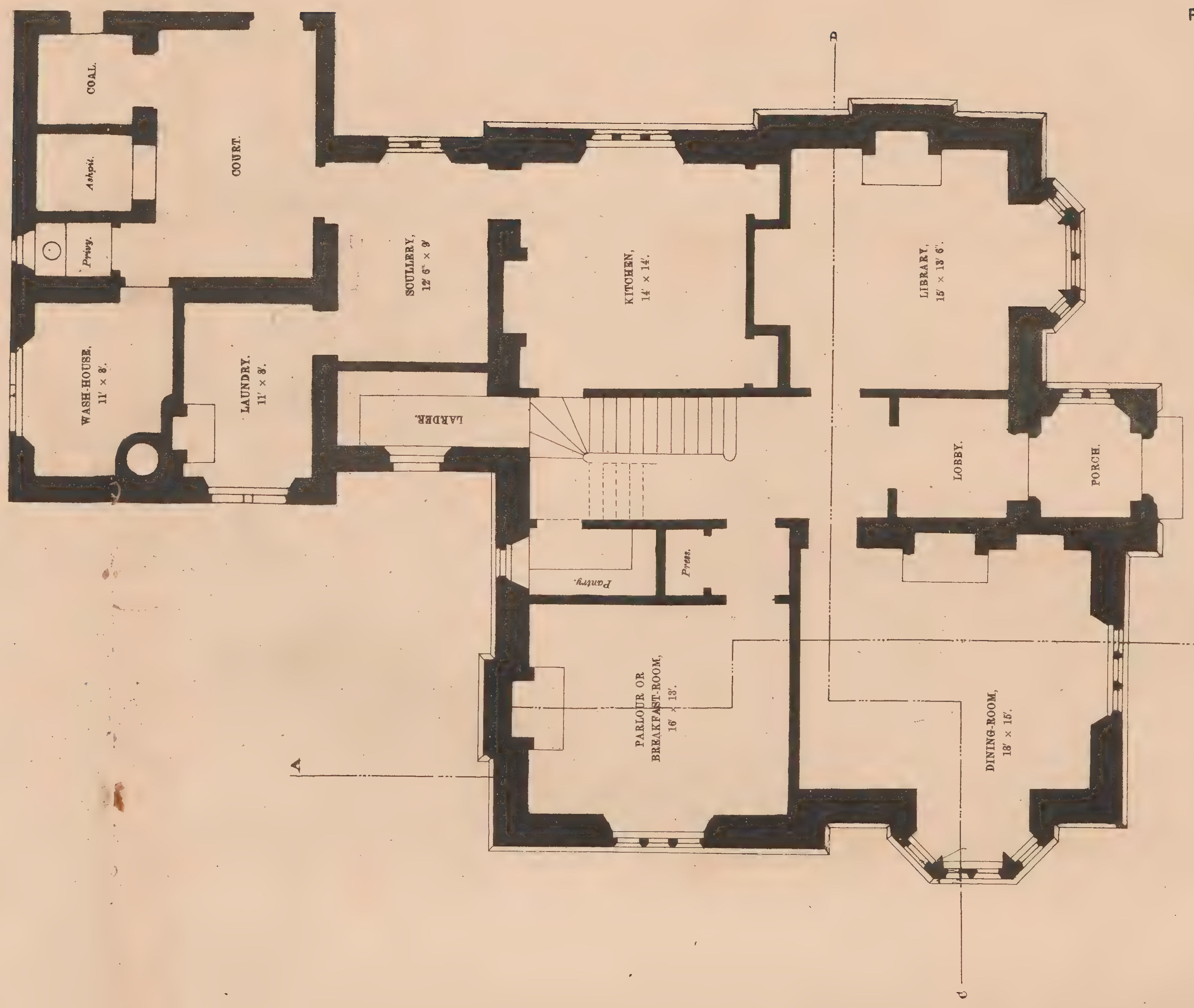

CAP AND BASE OF PIERS
CORNICE AND STRING
BASE AND SILL COURSE
UPPER CORNICE
STOPPED ENDS TO CHAMFER DOORWAY
MULLION
HEAD OF BOTTOM WINDOWS
ARCHITRAVE TO DOORWAY
PIER
SECTION

PLAN OF A VILLA.

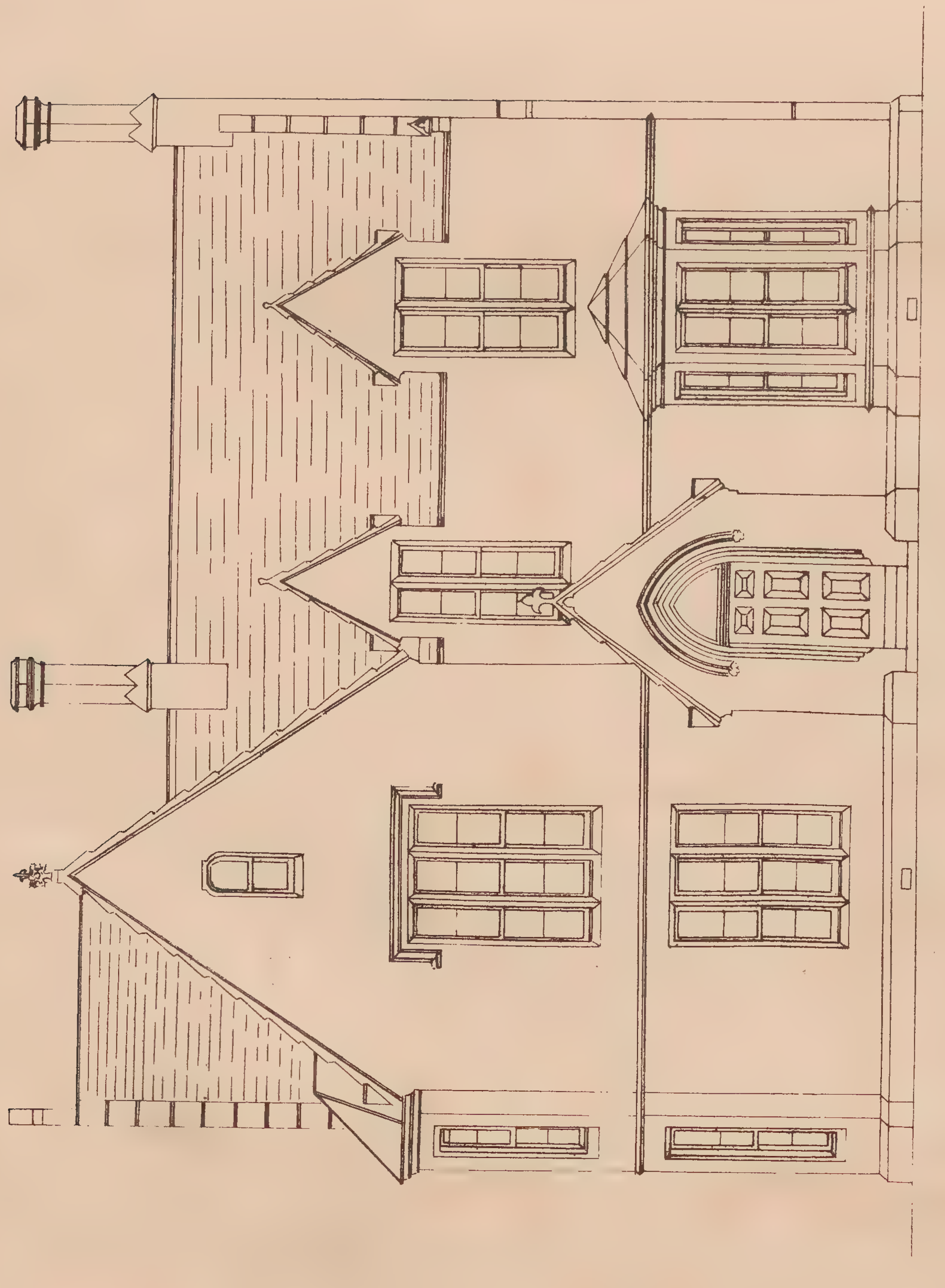
PLATE IV



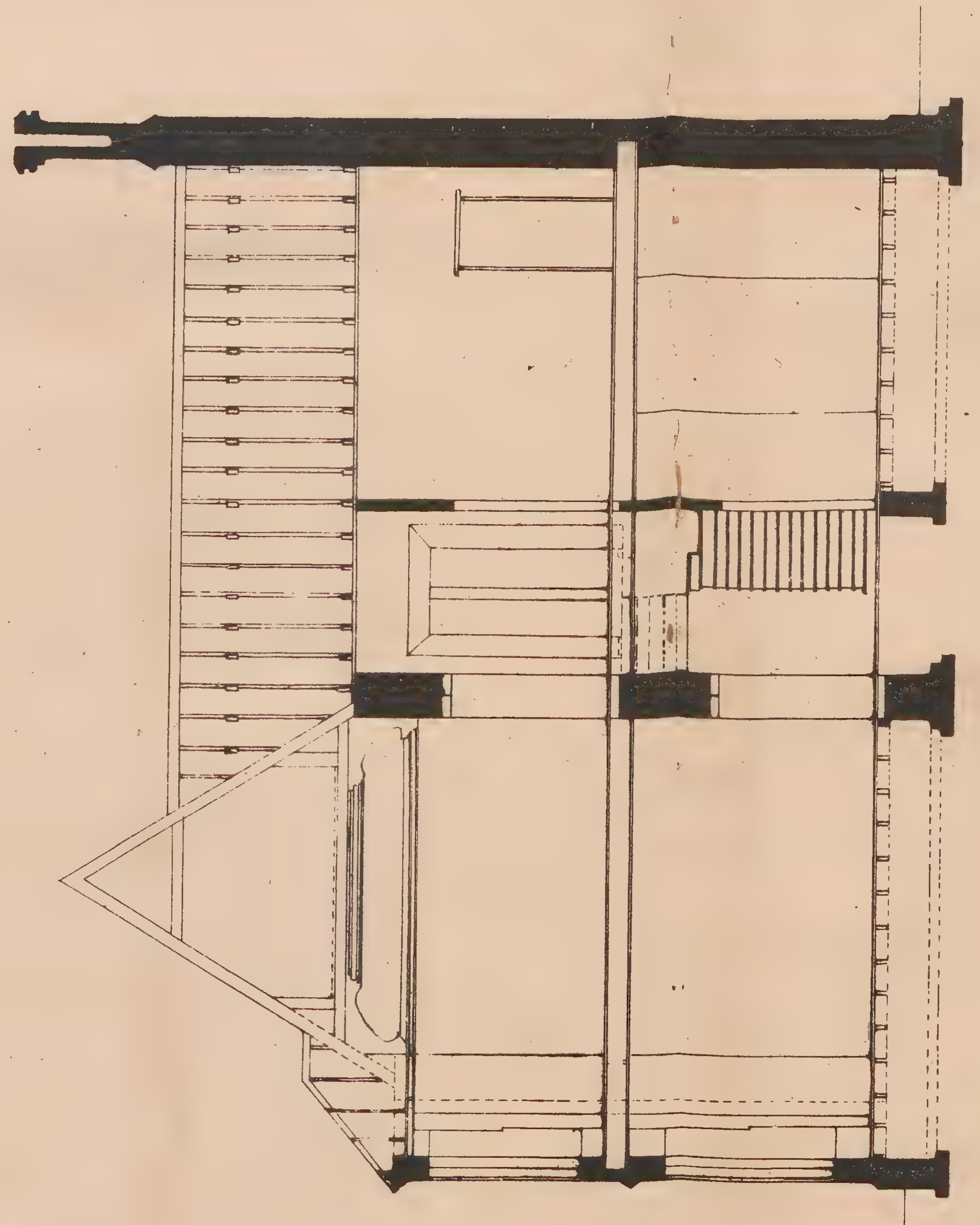
SECTION ON LINE A B.


COAL
Ashpit.
COURT.
Privy.
WASH-HOUSE. 11' × 8'.
LAUNDRY. 11' × 8'.
SCULLERY. 12' 6" × 9'.
KITCHEN. 14' × 14'.
LIBRARY. 15' × 13' 6".
LARDER.
LOBBY.
PORCH.
Pantry.
Press.
PARLOUR OR BREAKFAST-ROOM. 16' × 13'.
DINING-ROOM. 18' × 15'.
A
B
C
D

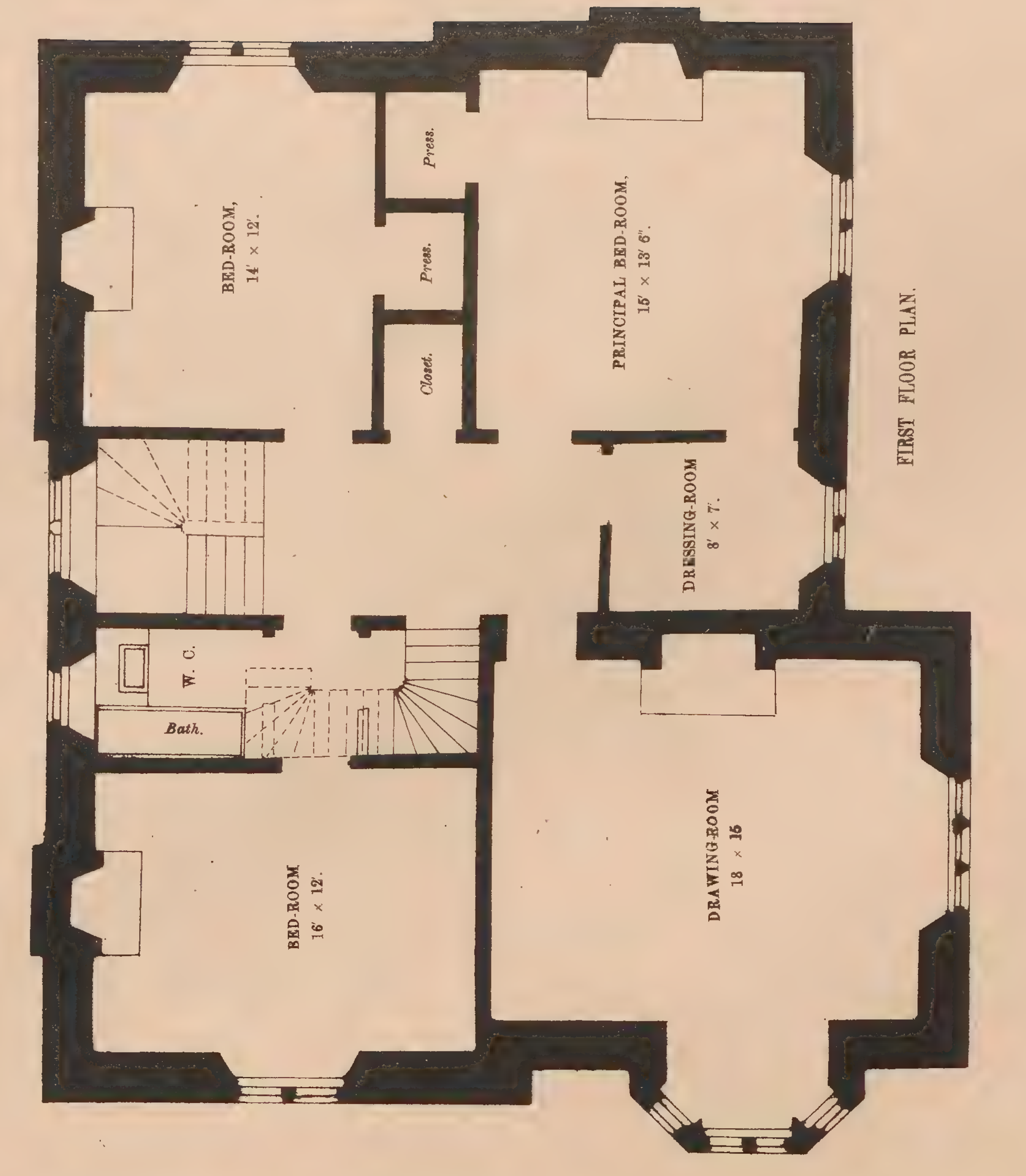
GROUND PLAN.



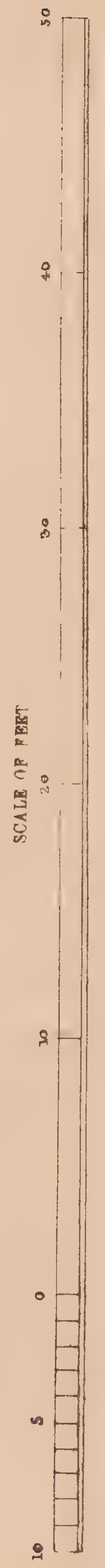
FRONT ELEVATION.



SECTION ON LINE C D.


BED-ROOM. 14' × 12'.
Press.
Press.
Closet.
PRINCIPAL BED ROOM. 15' × 13' 6".
DRESSING-ROOM. 8' × 7'.
W. C.
Bath.
BED-ROOM. 16' × 12'.
DRAWING-ROOM. 18' × 15'.

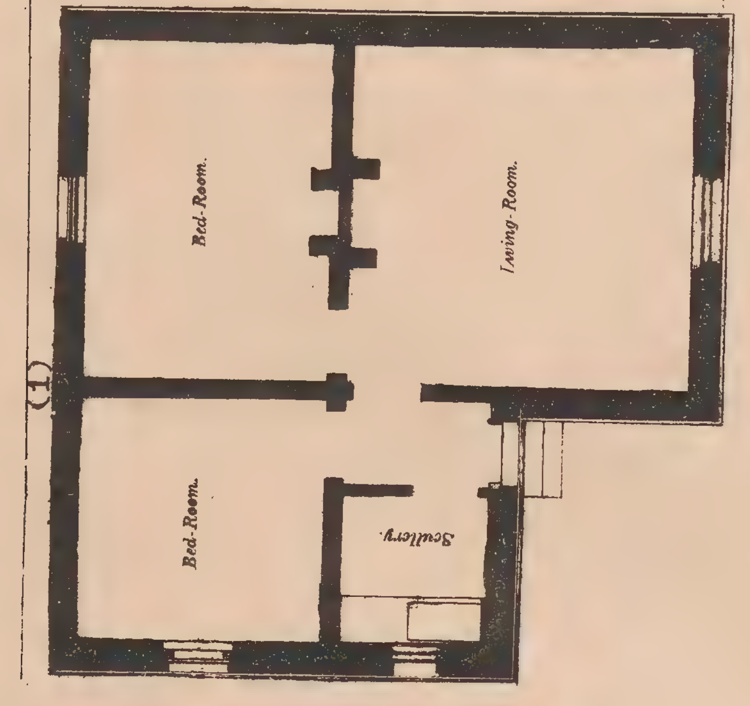
FIRST FLOOR PLAN.


SCALE OF FEET
10
5
0
10
20
30
40
50

PLANS AND ELEVATIONS OF LABOURERS' COTTAGES AND OUT-BUILDINGS.

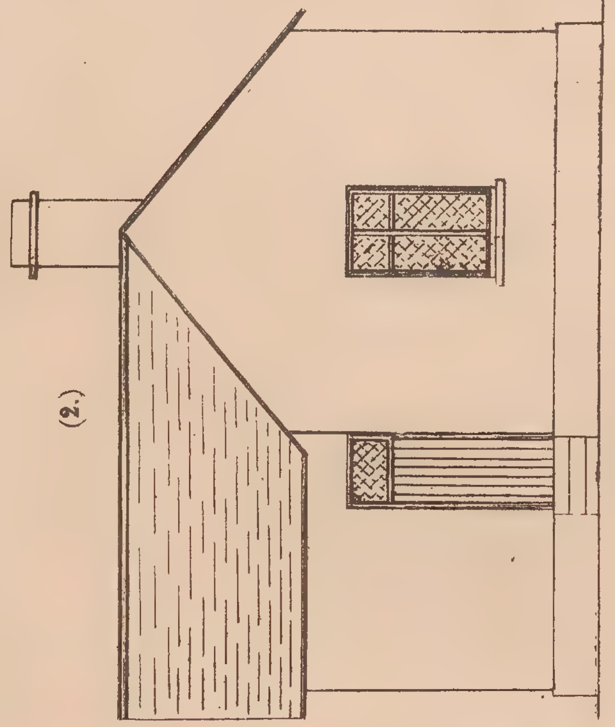
DETACHED SINGLE STORIED COTTAGE.

(1.)


Bed-Room.
Living Room.
Bed-Room.
Scullery.

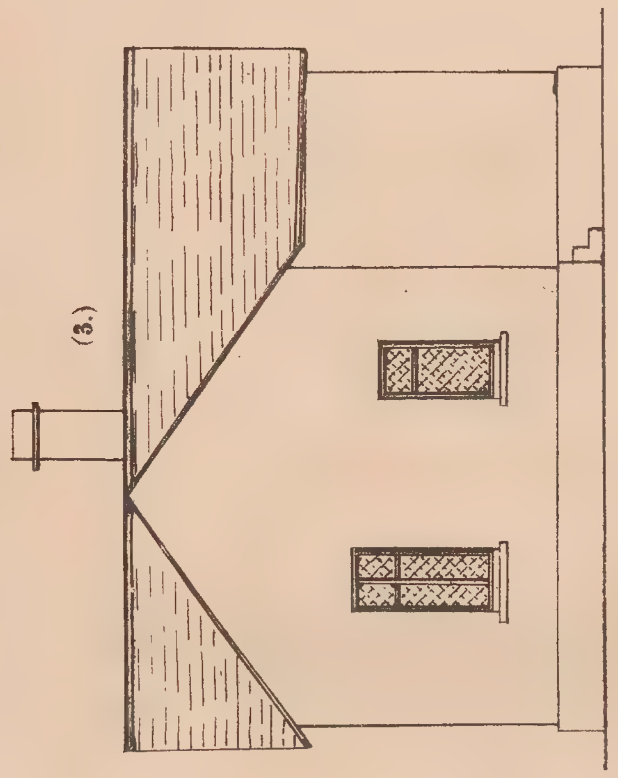
PLAN

(2.)



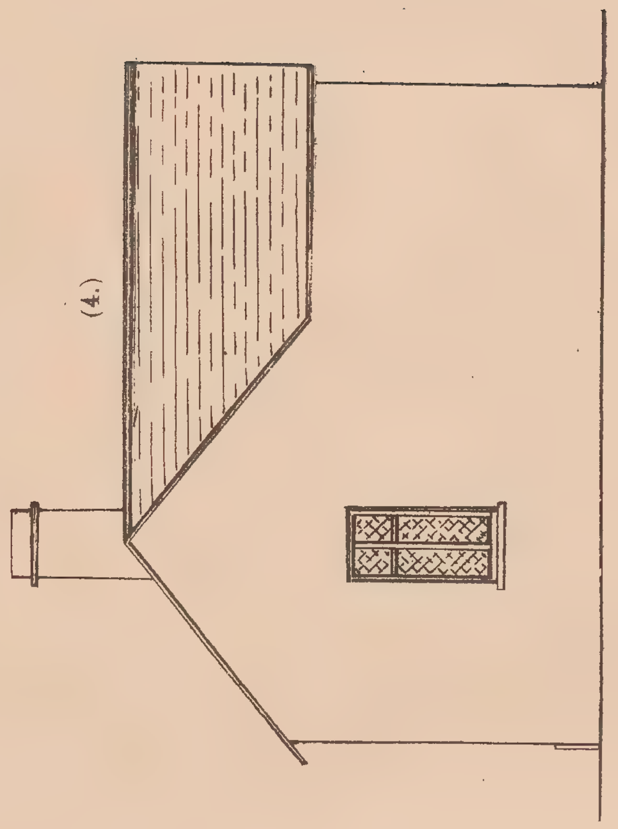
FRONT ELEVATION

(3.)



END ELEVATION.

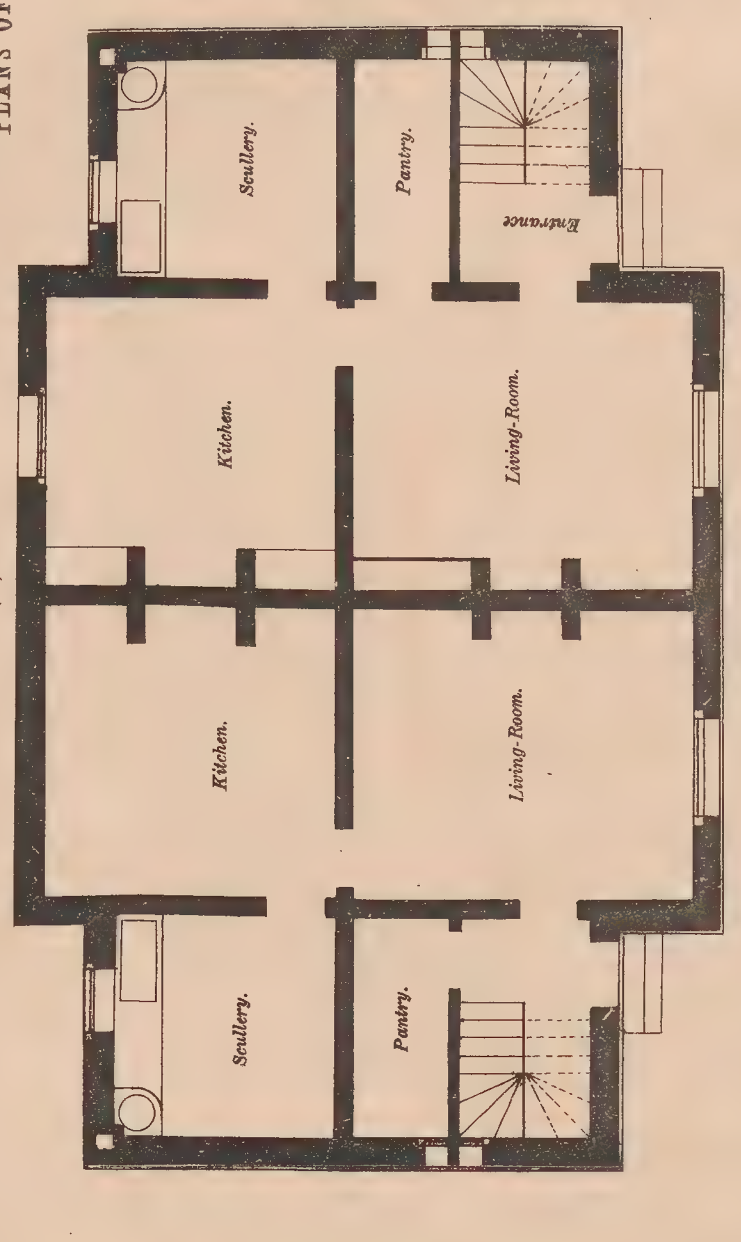
(4.)



BACK ELEVATION.

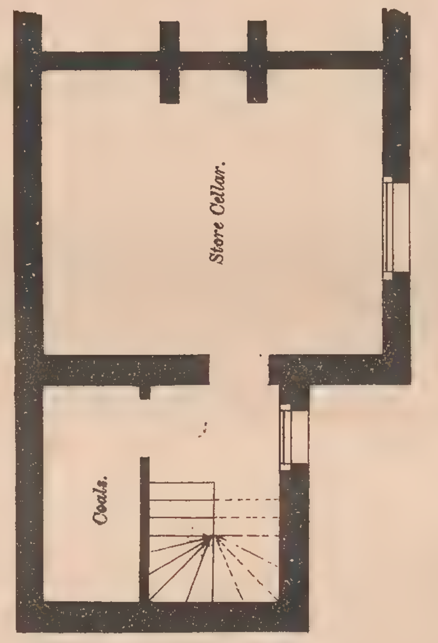
PLANS OF COTTAGES SEMI-DETACHED HAVING EQUAL ACCOMMODATION.

(5.)


Scullery.
Pantry.
Entrance
Kitchen.
Living-Room.
Kitchen.
Living-Room.
Scullery.
Pantry.

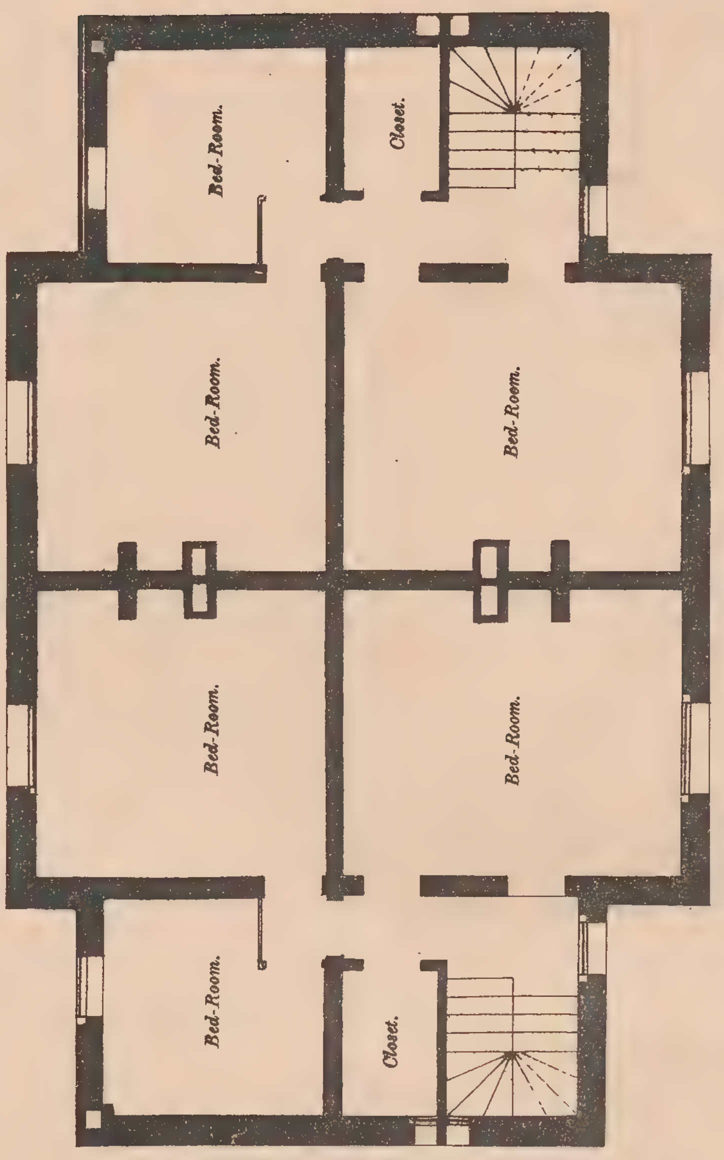
GROUND PLAN.

(6.)


Store Cellar.
Coals.

CELLAR PLAN.

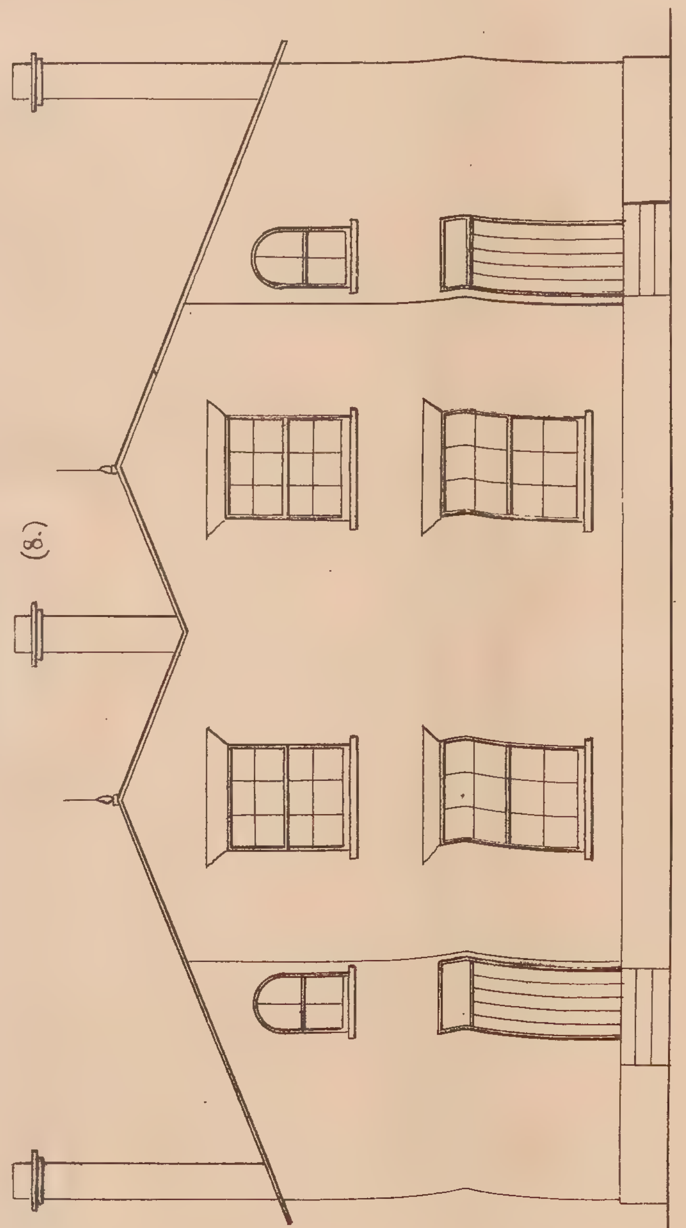
(7.)


Bed-Room.
Closet.
Bed-Room.
Bed-Room.
Bed-Room.
Bed-Room.
Bed-Room.
Closet.

CHAMBER PLAN.

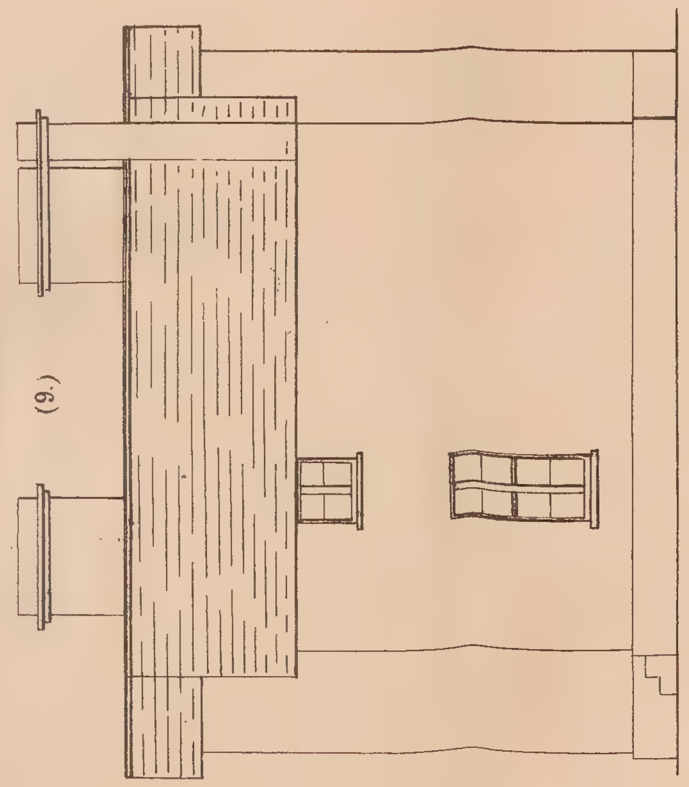
ELEVATIONS OF SEMI-DETACHED COTTAGES IN FIGS. 5, 6, AND 7.

(8.)



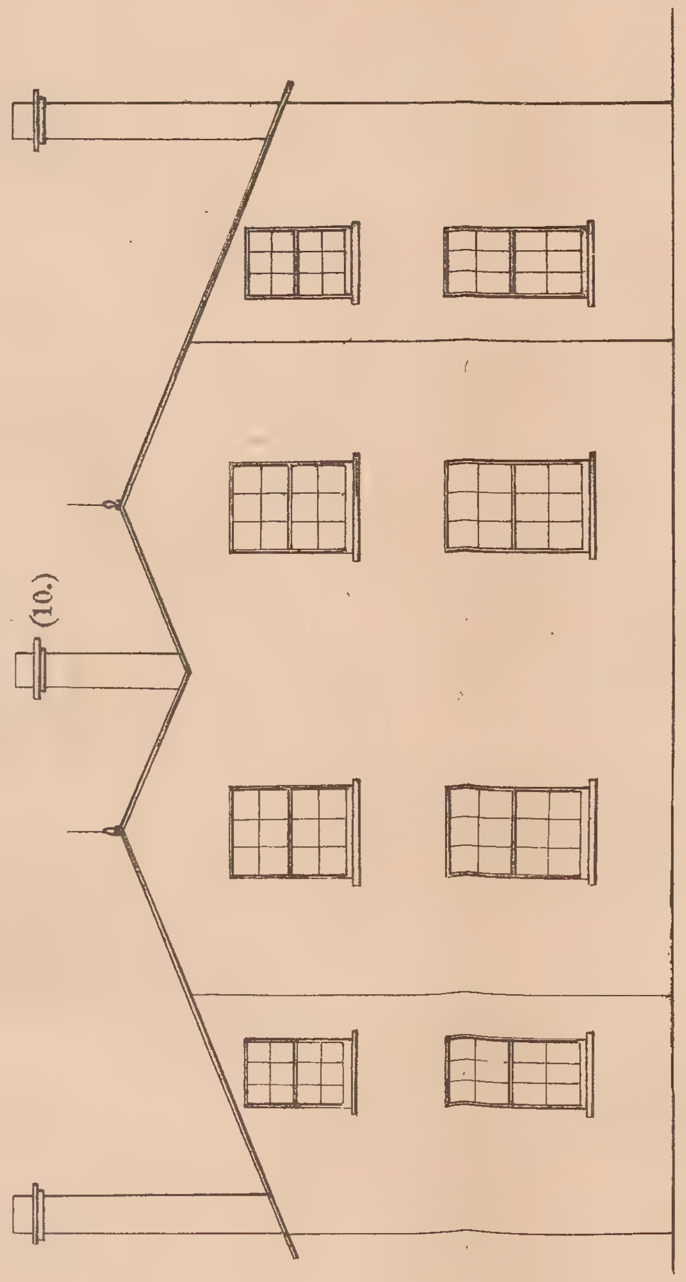
FRONT ELEVATION.

(9.)



END ELEVATION

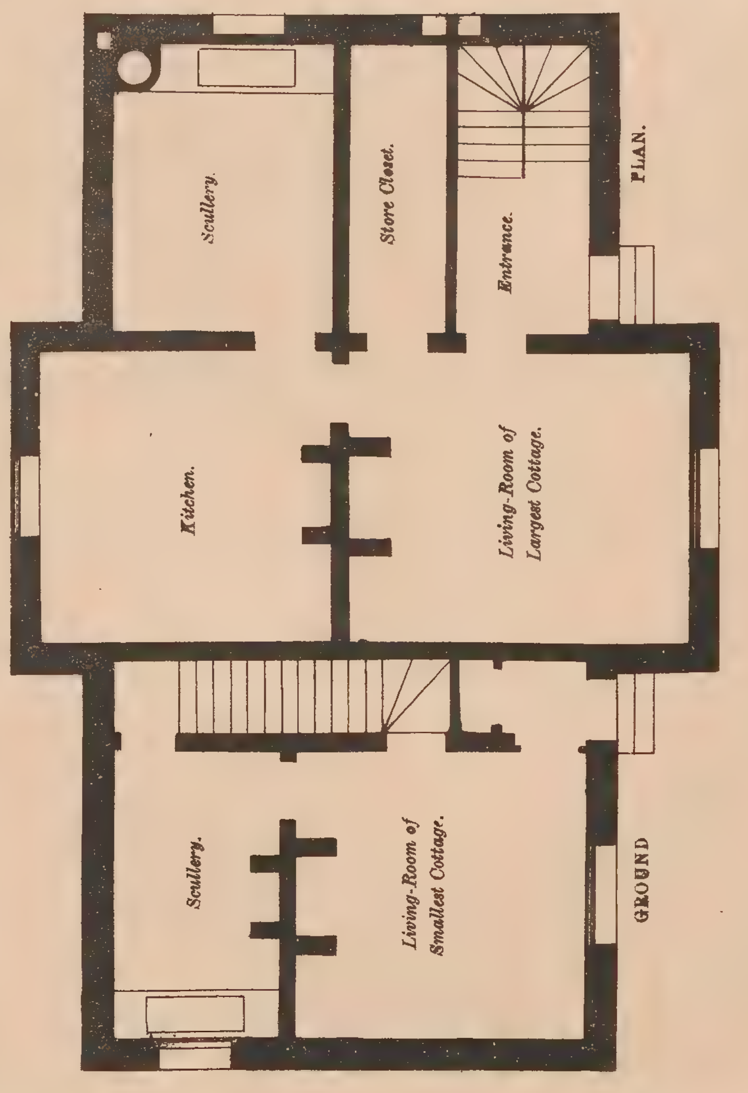
(10.)



BACK ELEVATION.

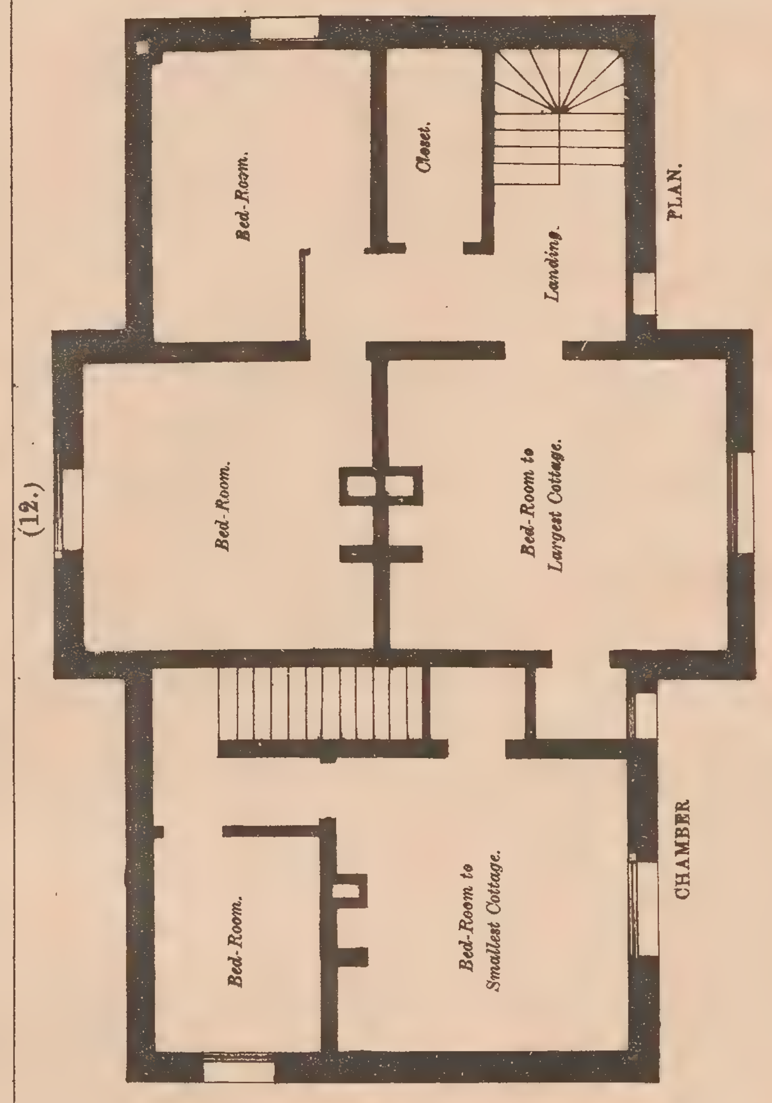
PLANS OF SEMI-DETACHED COTTAGES, HAVING UNEQUAL ACCOMMODATION.

(11.)


Scullery.
Store Closet.
Entrance.
Kitchen.
Living-Room of Largest Cottage.
Scullery.
Living-Room of Smallest Cottage.

GROUND PLAN.

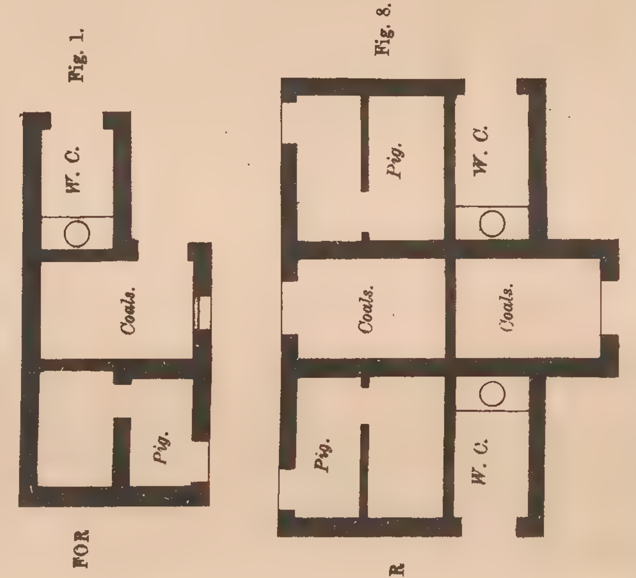
(12.)


Bed-Room.
Closet.
Landing.
Bed-Room.
Bed-Room to Largest Cottage.
Bed-Room.
Bed-Room to Smallest Cottage.

CHAMBER PLAN.

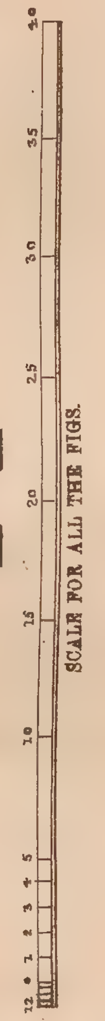
(13.)

OUT-BUILDINGS

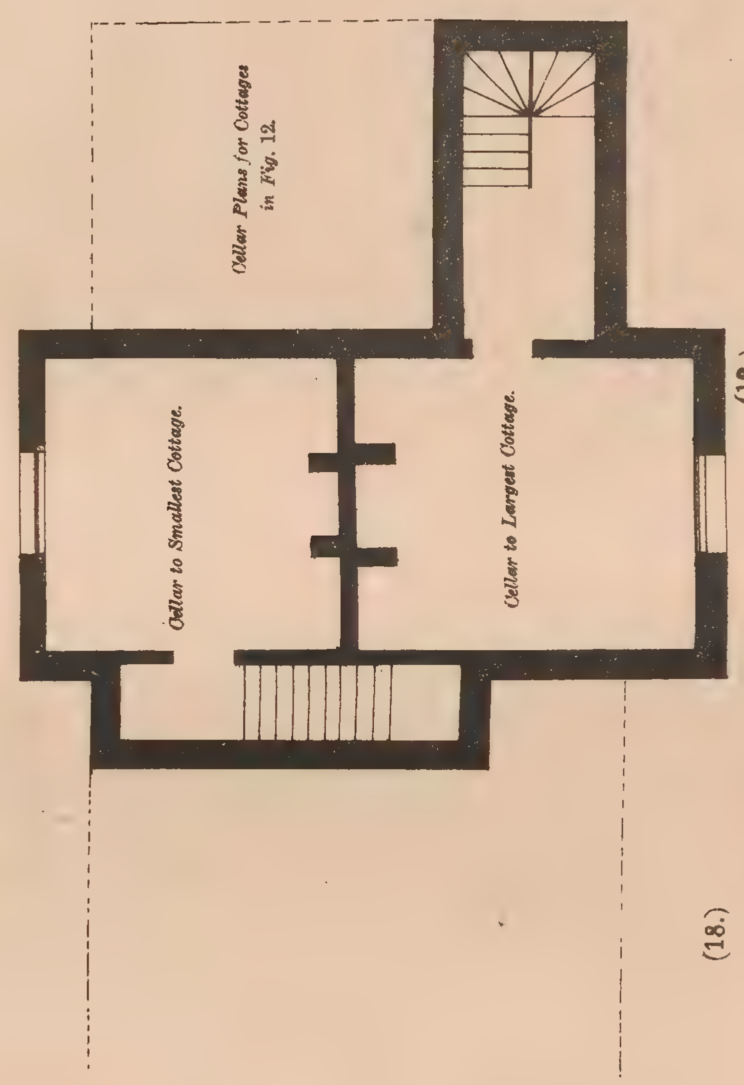

W. C.
Coals.
Pig.
Pig.
W. C.
Coals.
Coals.
Pig.
W. C.

FOR Fig. 1.

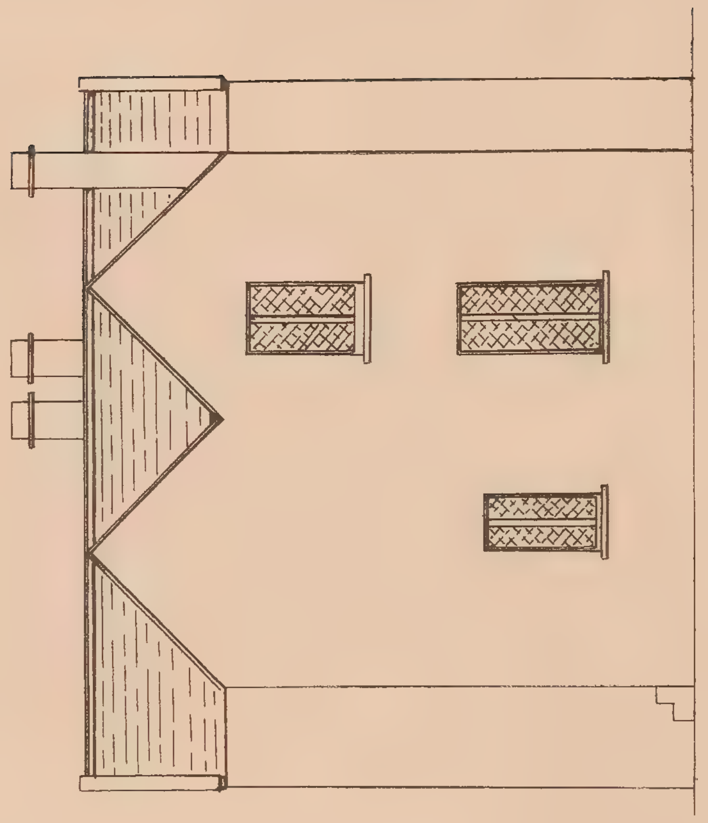
FOR Fig. 8.



SCALE FOR ALL THE FIGS.

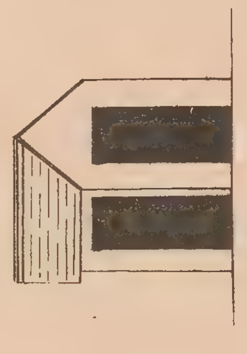

Cellar to Smallest Cottage.
Cellar to Largest Cottage.

Cellar Plans for Cottages in Fig. 12.



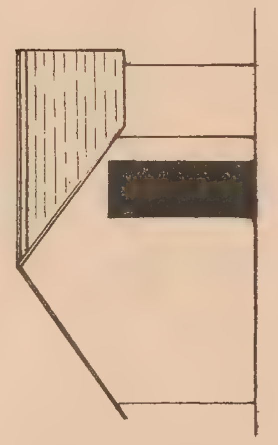
END ELEVATION OF COTTAGE PLAN IN Fig. 11.

(20.)



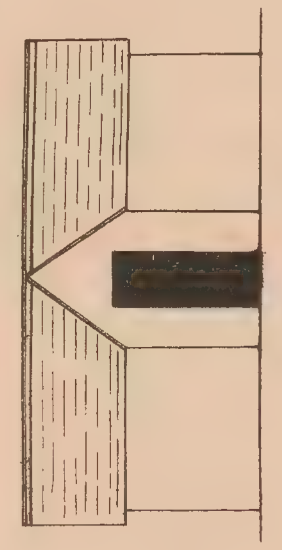
END ELEVATION OF Fig. 13.

(19.)



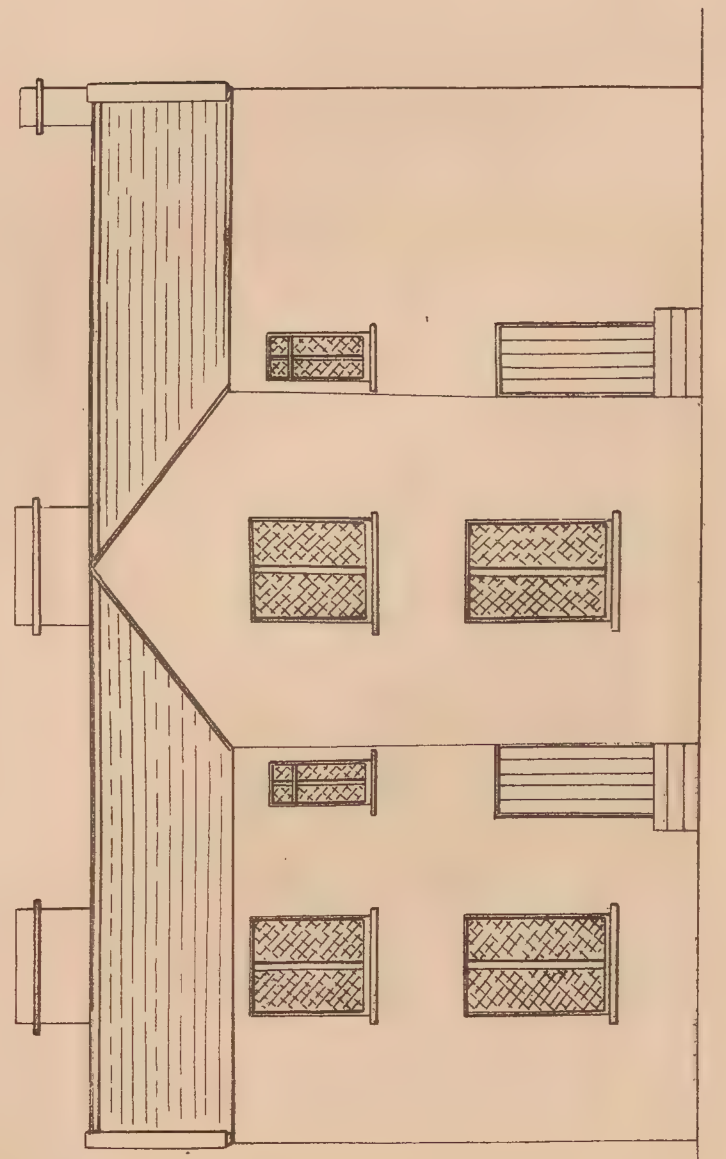
END ELEVATION OF Fig. 14.

(18.)



FRONT ELEVATION OF OUT-BUILDINGS.

(15.)

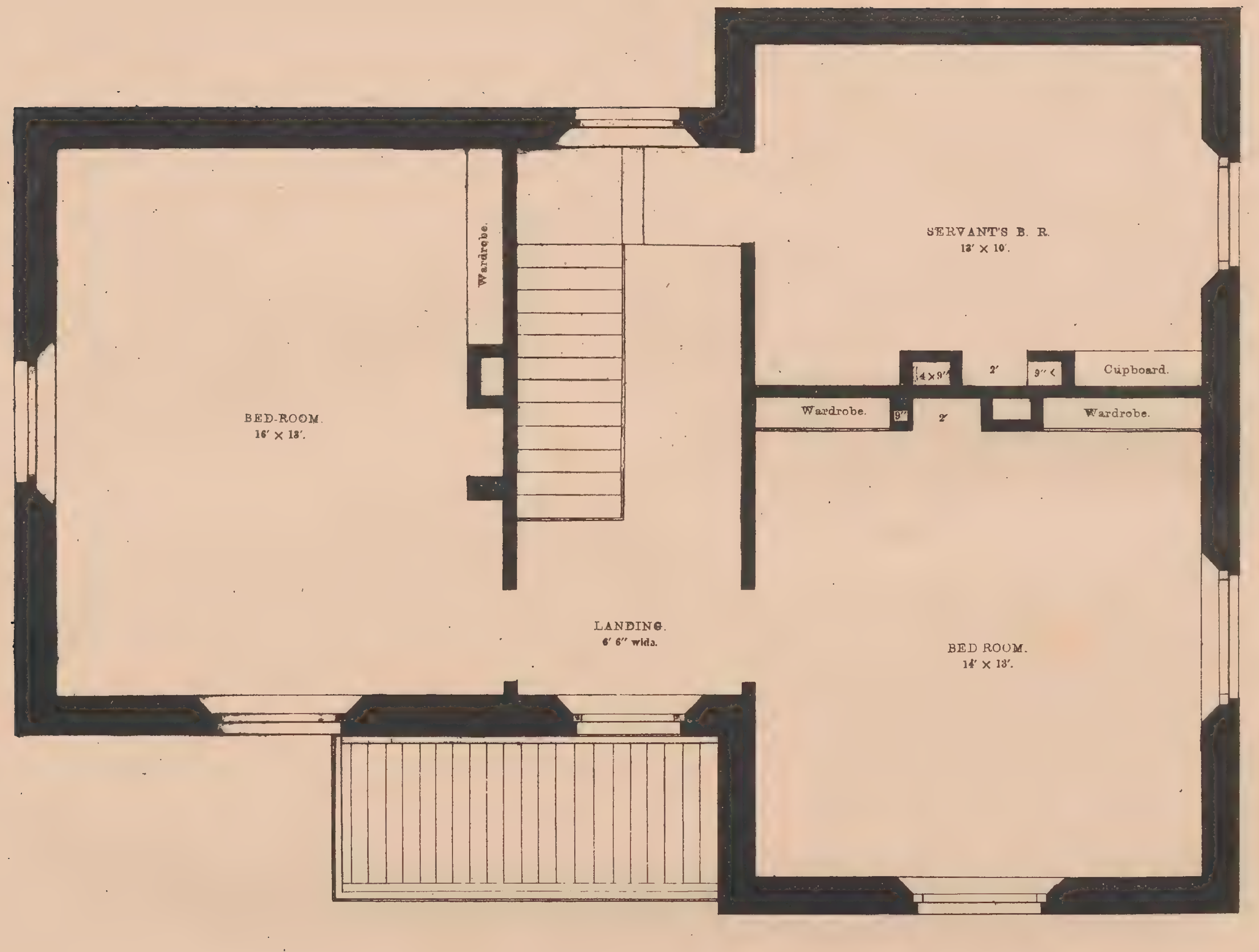


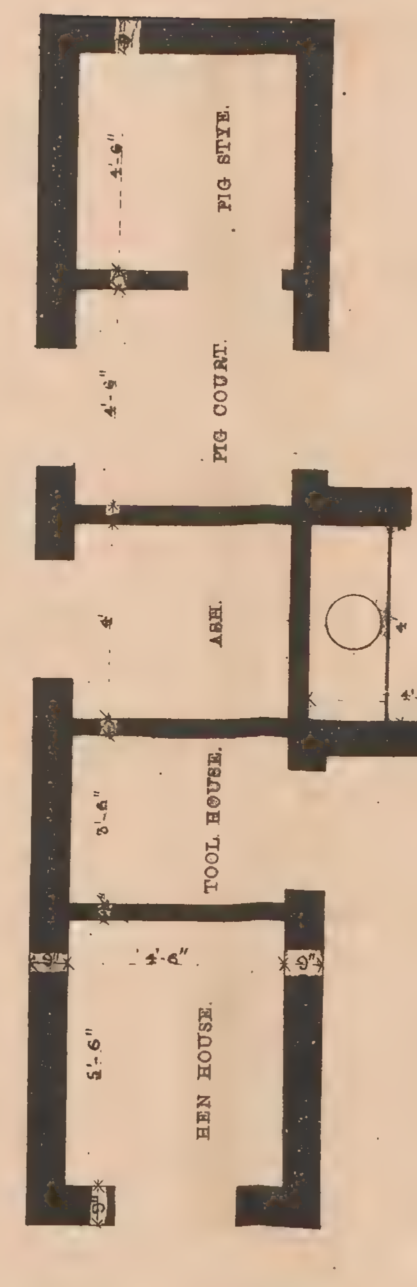
FRONT ELEVATION OF COTTAGE IN Fig. 11.

DESIGN FOR SUBURBAN VILLA OR FARM-HOUSE.

ILLUSTRATING ESSAY FIRST,

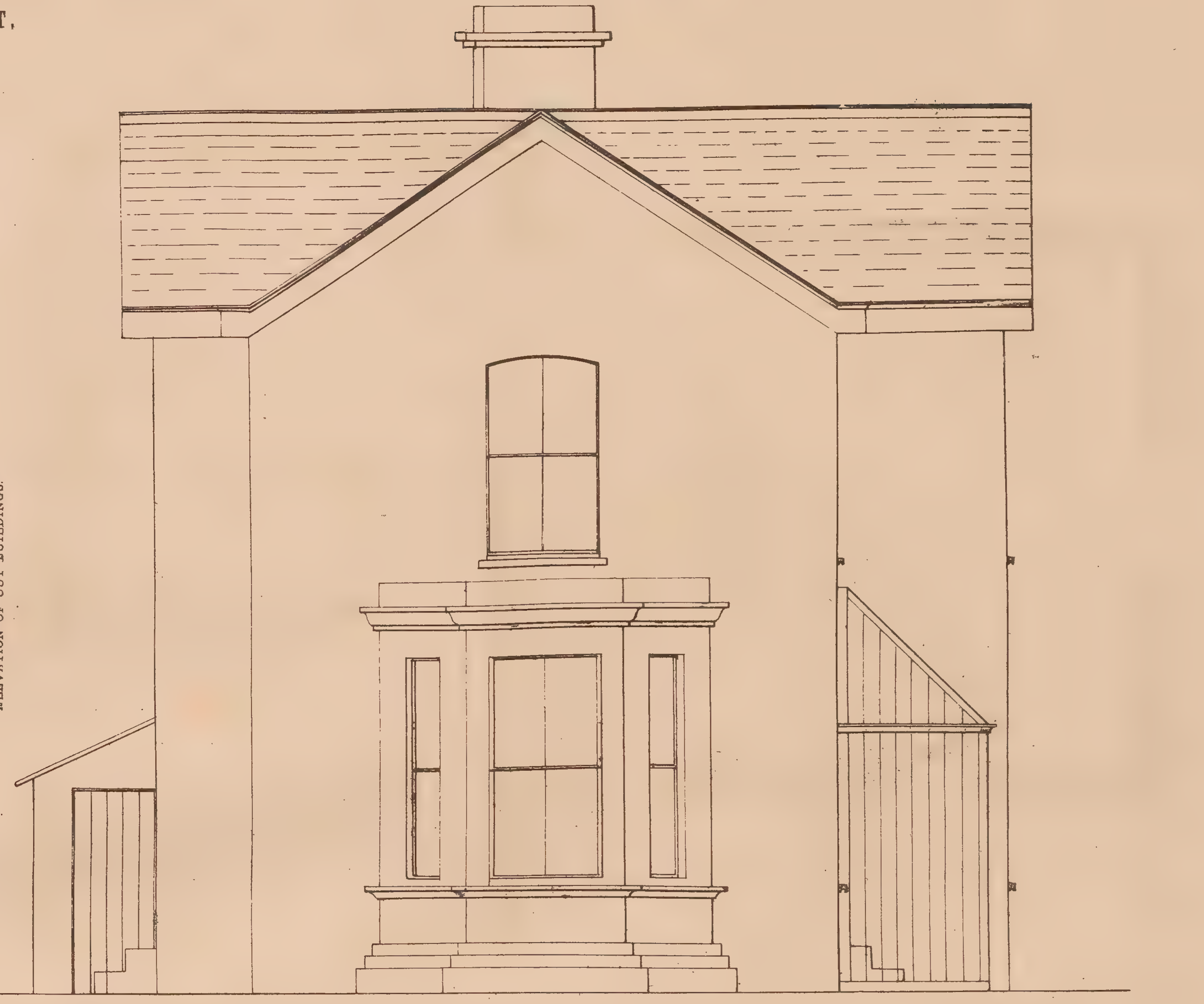
CHAMBER PLAN.


Wardrobe.
BED-ROOM.
16' × 13'.
SERVANT'S B. R.
13' × 10'.
4×9"
2'
9"
Cupboard.
Wardrobe.
9"
2'
Wardrobe.
LANDING.
6' 6" wide.
BED ROOM.
14' × 13'.


PIG STYE.
4'-6"
PIG COURT.
4'-6"
ASH.
4'
PRIVY.
4'-6'
TOOL HOUSE.
3'-6"
4'-6"
9"
HEN HOUSE.
5'-6"
9"

ELEVATION OF OUT BUILDINGS.

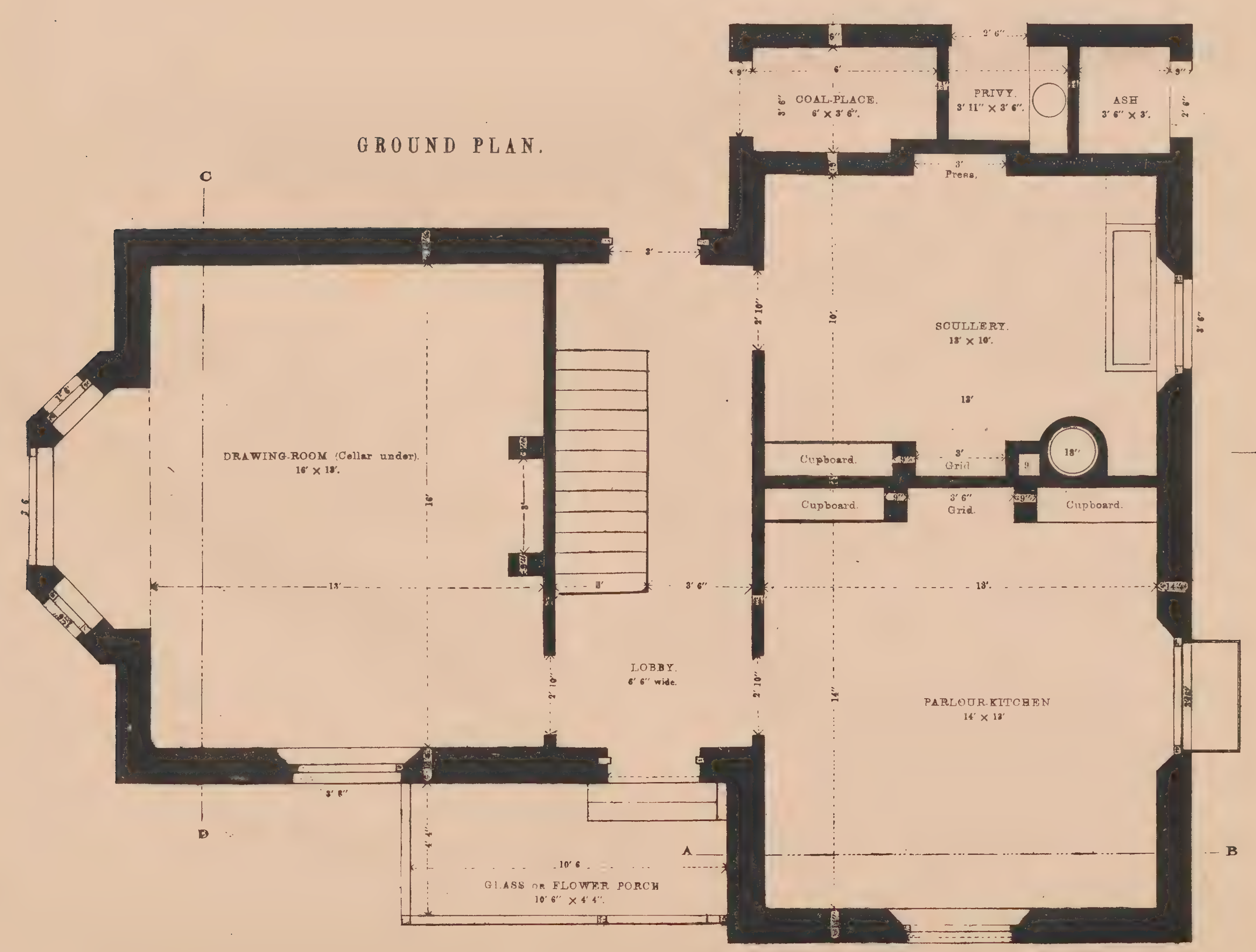
WEST ELEVATION.

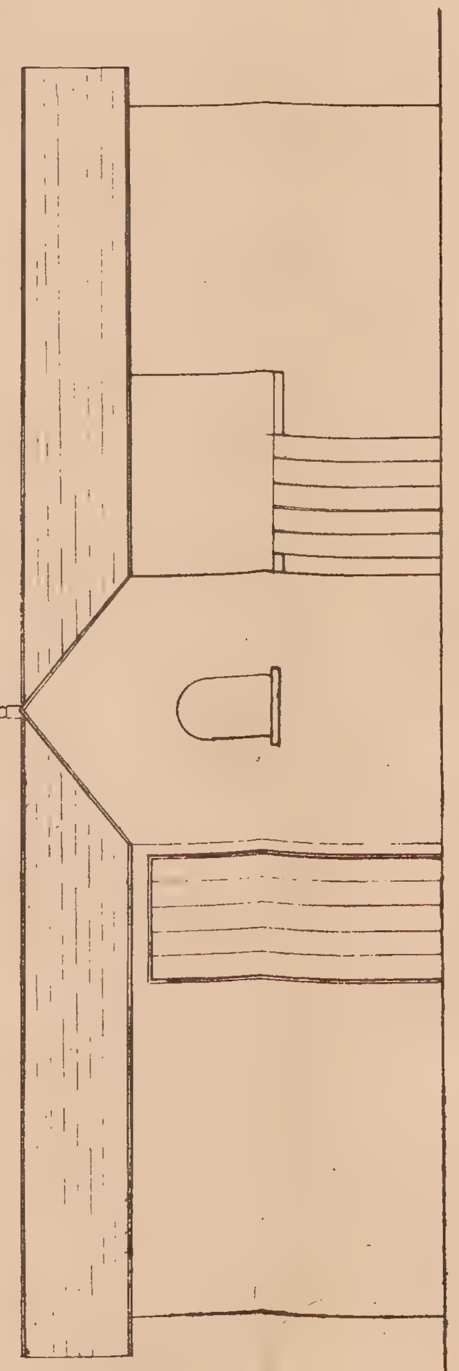


SCALE.

In
12
6
0
1
2
3
4
5
10
15
20
25
30
Ft

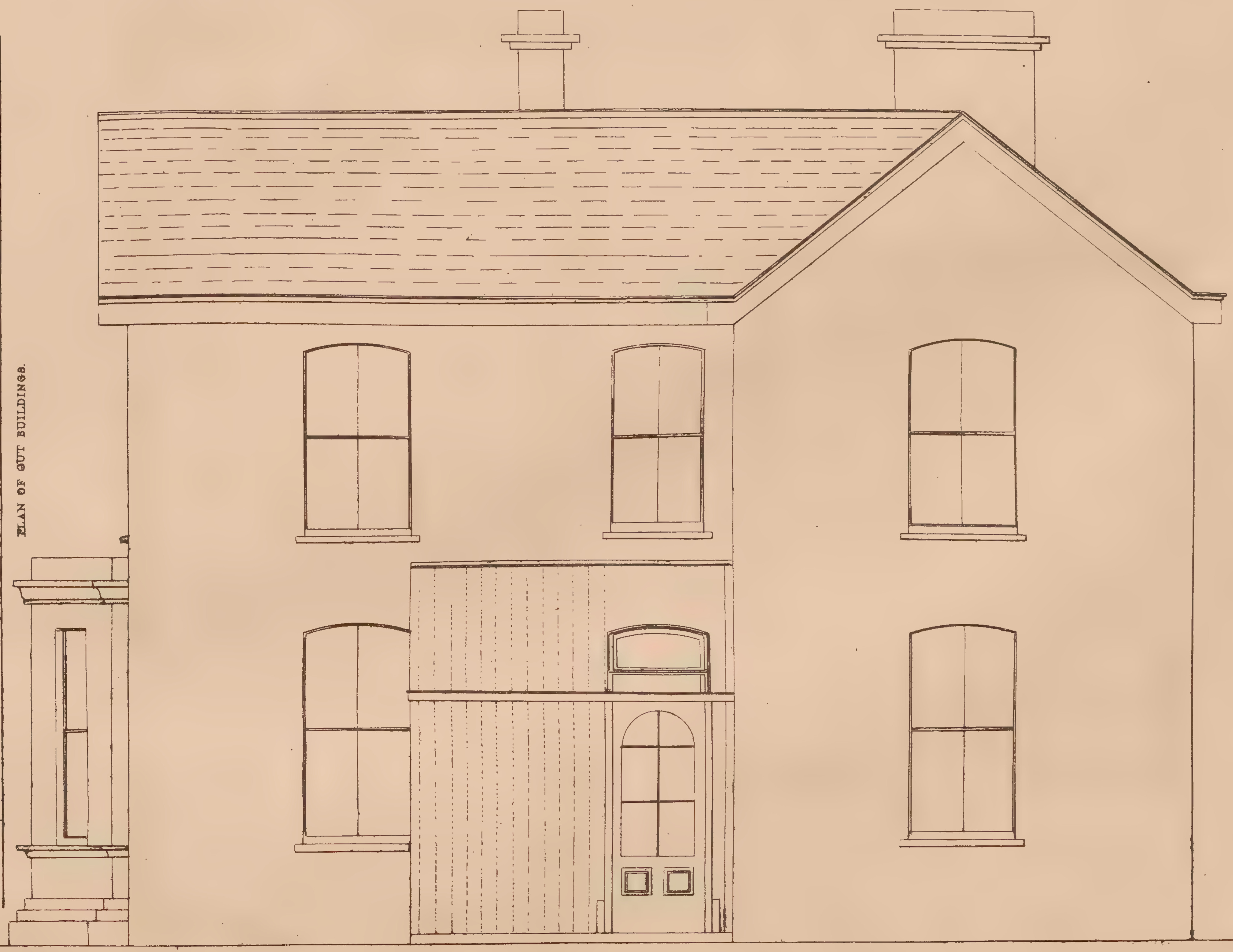
GROUND PLAN.


COAL-PLACE.
6' × 3' 6".
PRIVY.
3' 11" × 3' 6".
ASH
3' 6" × 3'.
2' 6"
6'
9"
3' 6"
2' 6"
3'
Press.
C
3'
2' 10"
10'
SCULLERY.
13' × 10'.
3' 6"
13'
DRAWING-ROOM (Cellar under).
16' × 13'.
16'
8'
Cupboard.
3'
Grid
9
18"
Cupboard.
3' 6"
Grid.
Cupboard.
13'
8'
3' 6"
13'.
2' 10"
LOBBY.
6' 6" wide.
2' 10"
14'
PARLOUR-KITCHEN
14' × 13'
3' 6"
D
4' 4"
10' 6
A
B
GLASS or FLOWER PORCH
10' 6" × 4' 4".



PLAN OF OUT BUILDINGS.

FRONT ELEVATION.

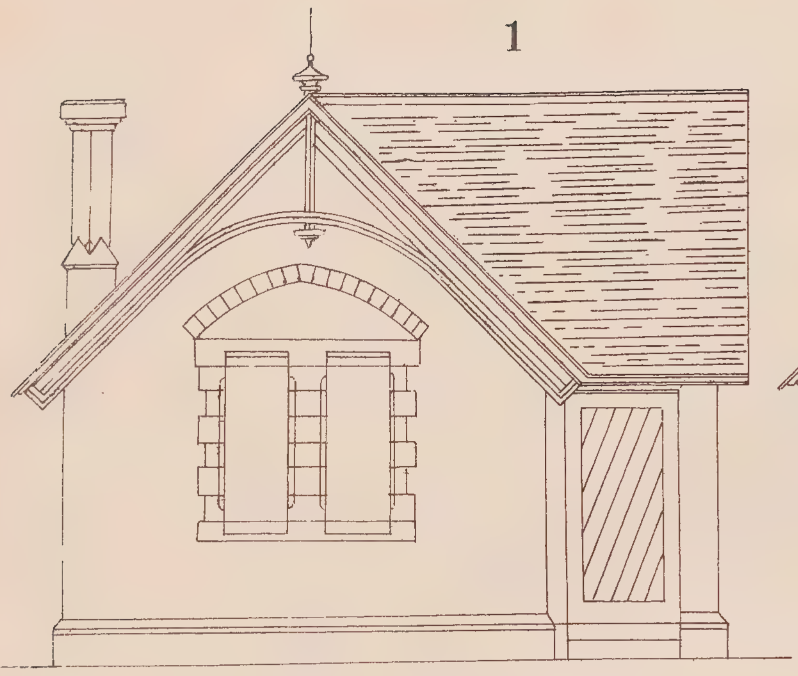


SUGGESTIVE DESIGNS FOR COTTAGE ELEVATIONS.

ILLUSTRATING ESSAY FIRST.

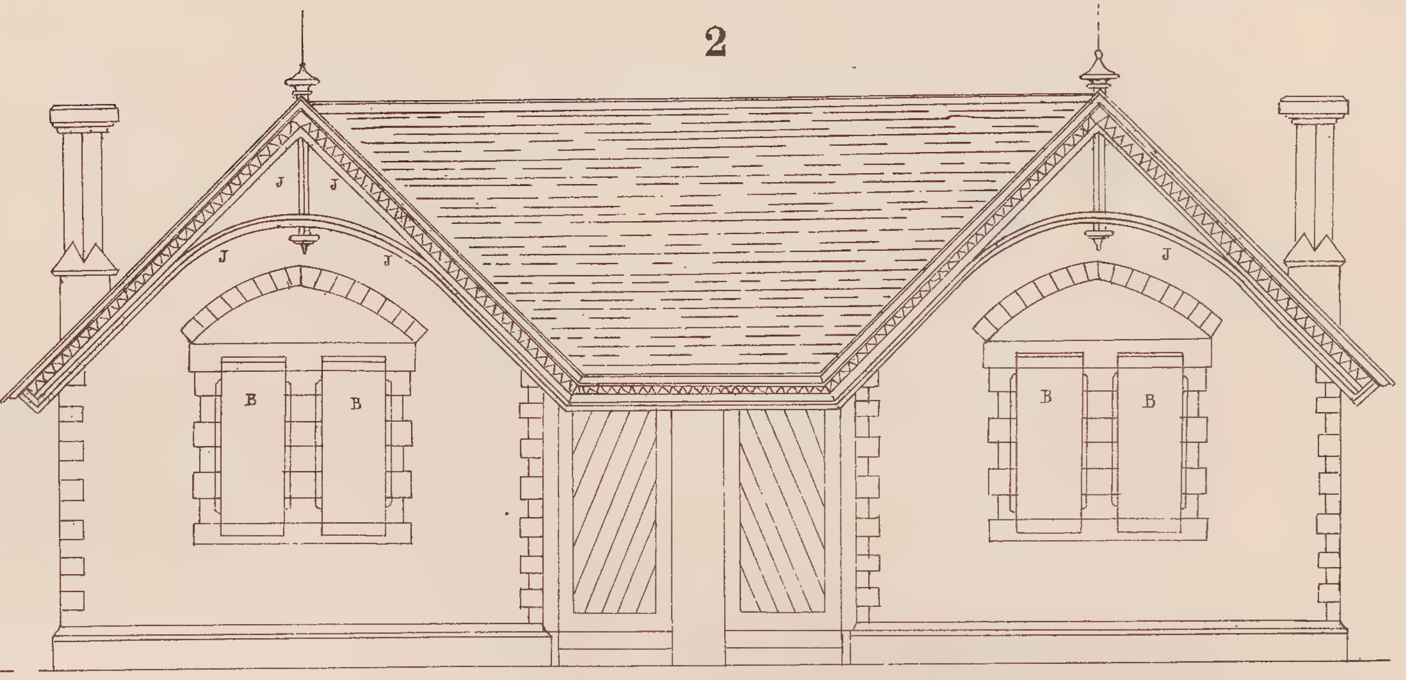
PLATE VII

1



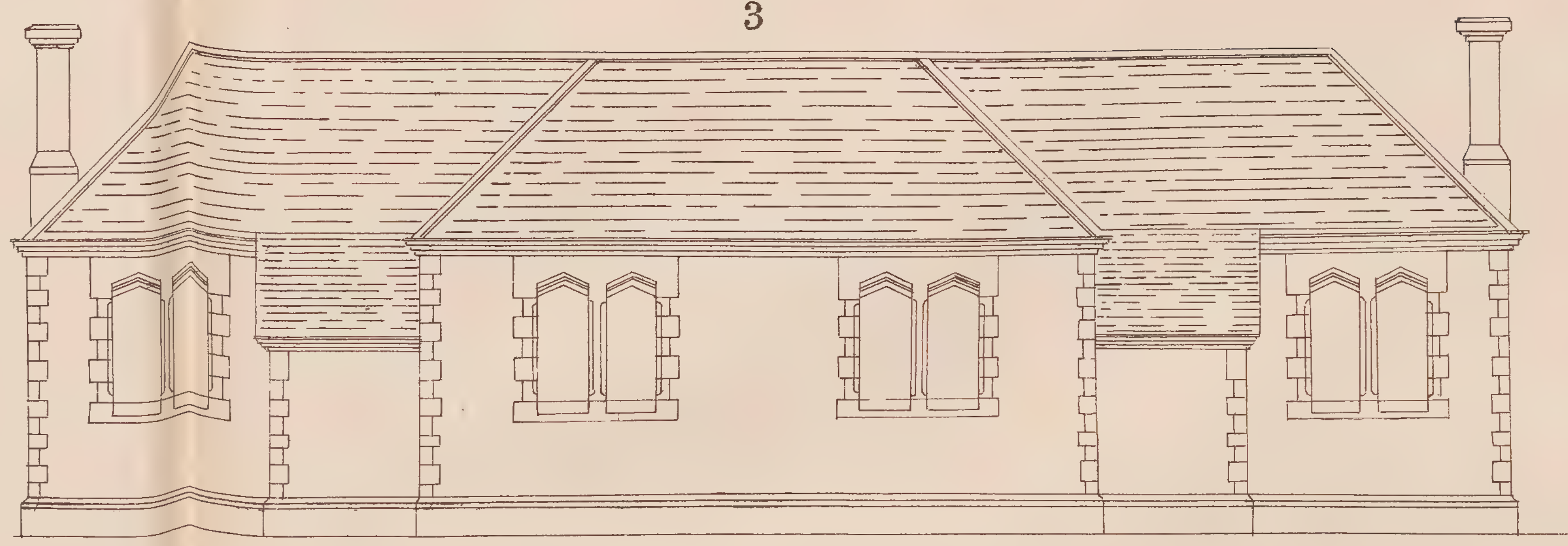
FRONT ELEVATION OF COTTAGE DETACHED.
Plan in Fig. 2, par. 19, p. 5, Essay First.

2



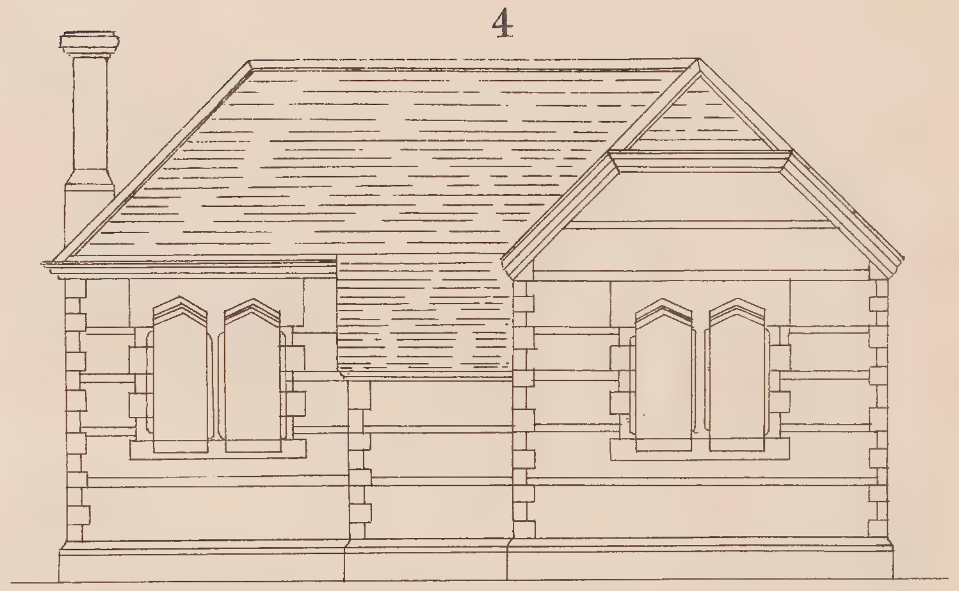
FRONT ELEVATION OF COTTAGE SEMI-DETACHED
Plan in Fig. 2, par. 19, p. 5, Essay First.

3

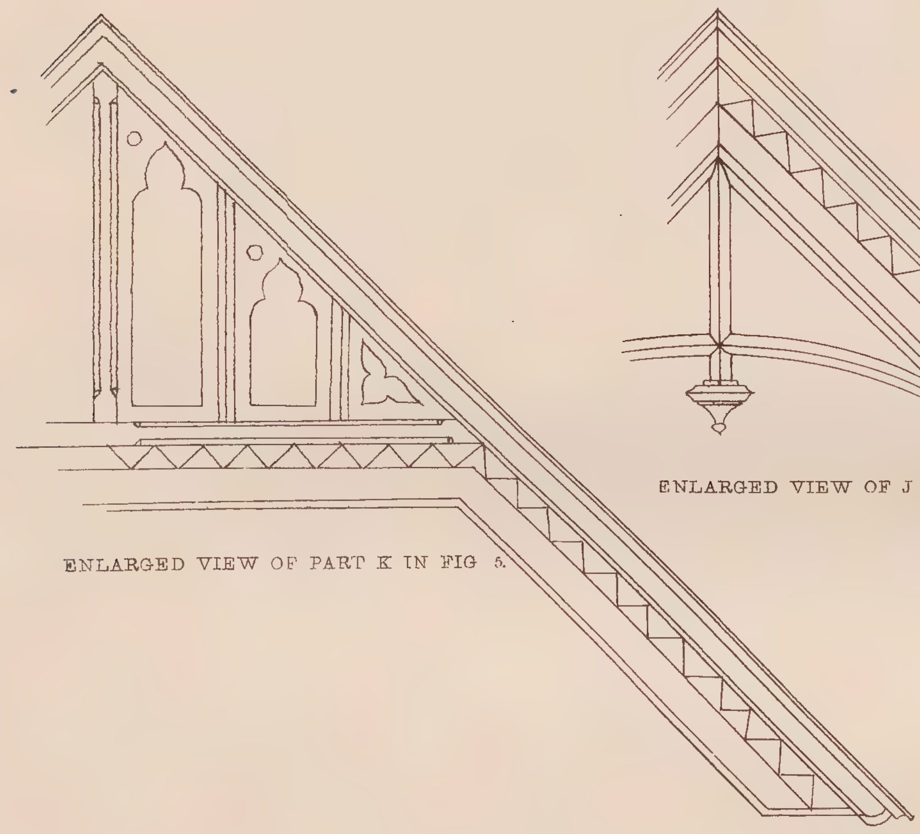


FRONT ELEVATION OF COTTAGE SEMI-DETACHED
Plan in Fig. 5, par. 21, p. 6, Essay First.

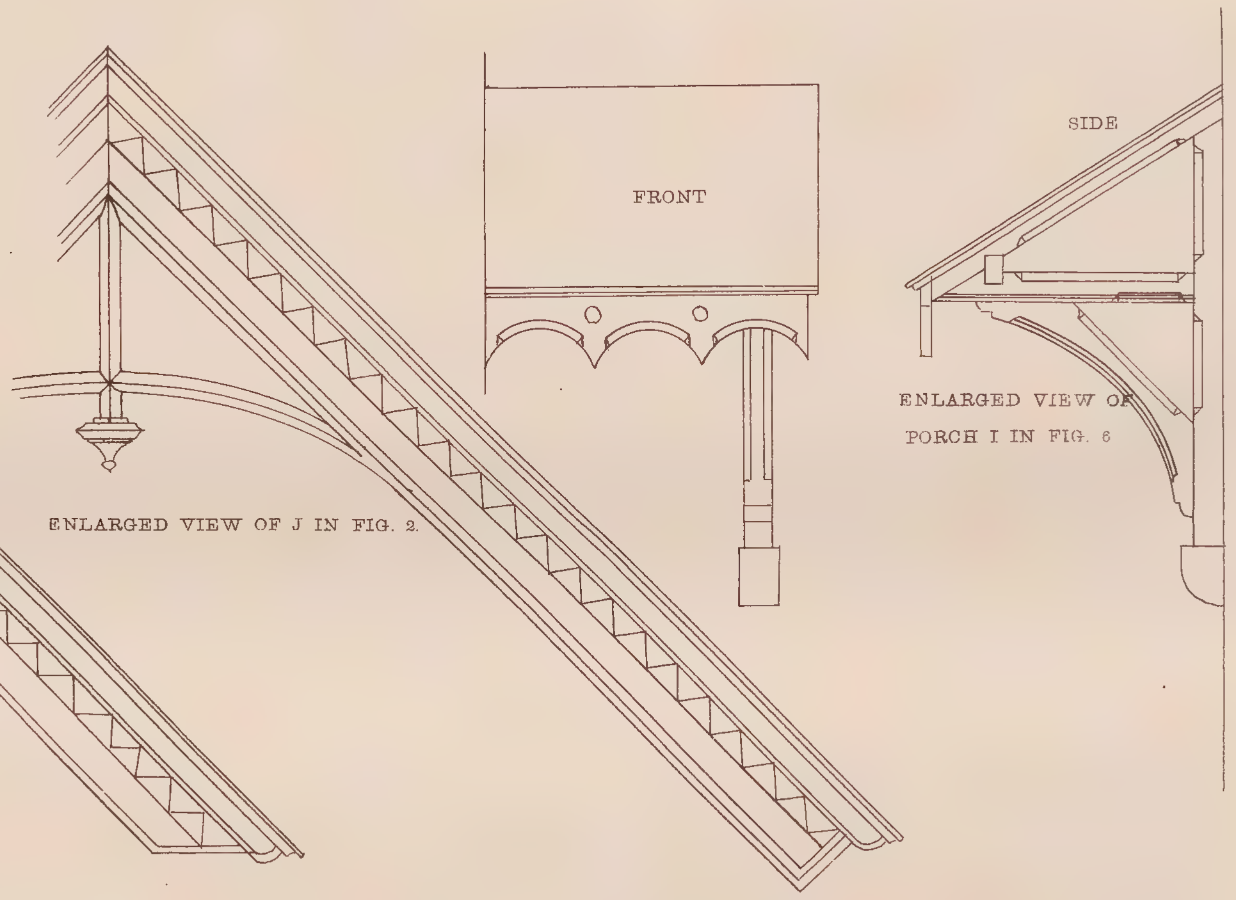
4



FRONT ELEVATION DETACHED.
Plan in fig. 5, par. 21, p. 6, Essay First.



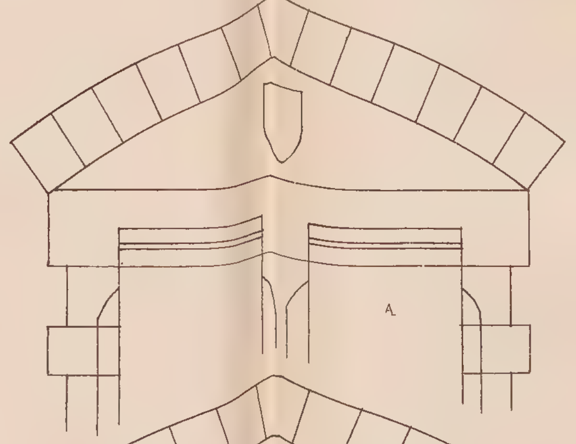
ENLARGED VIEW OF PART K IN FIG. 5.

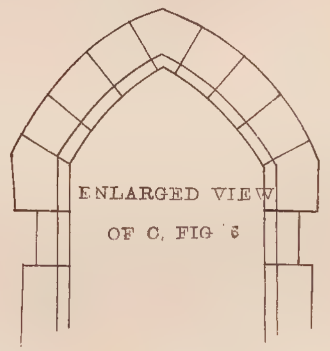


ENLARGED VIEW OF J IN FIG. 2.

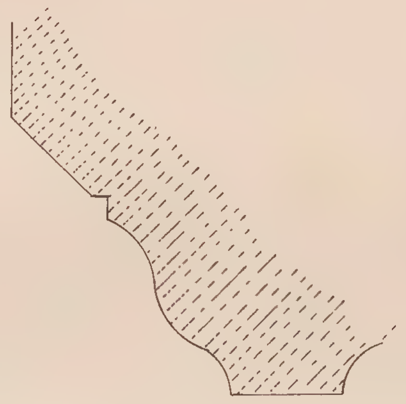
ENLARGED VIEW OF PORCH I IN FIG. 6.

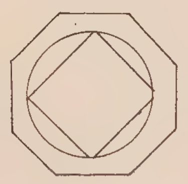
ENLARGED VIEW OF PART A IN FIG. 5.

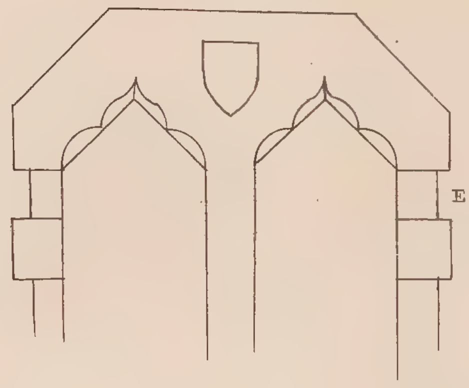




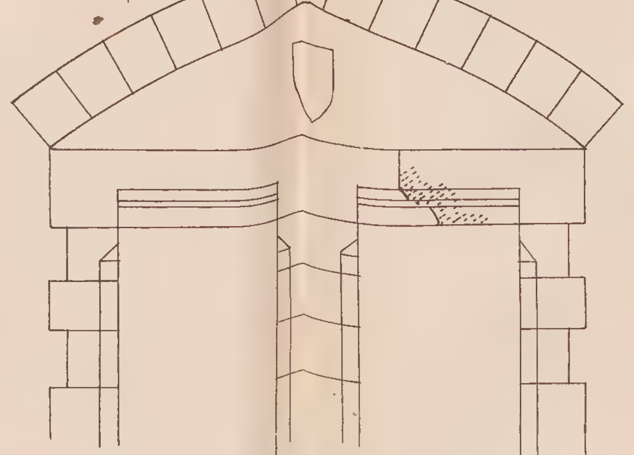
ENLARGED VIEW OF C, FIG. 5.



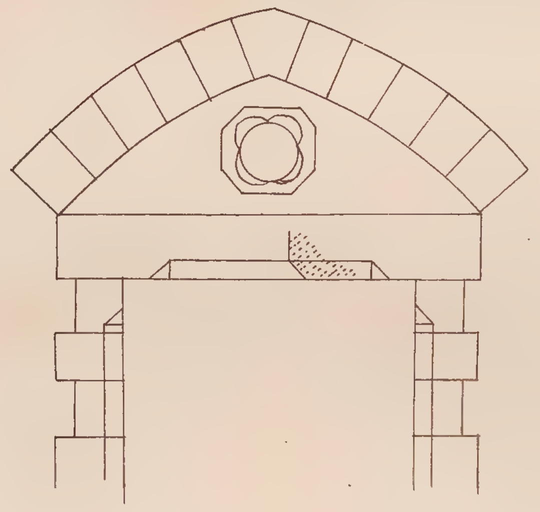




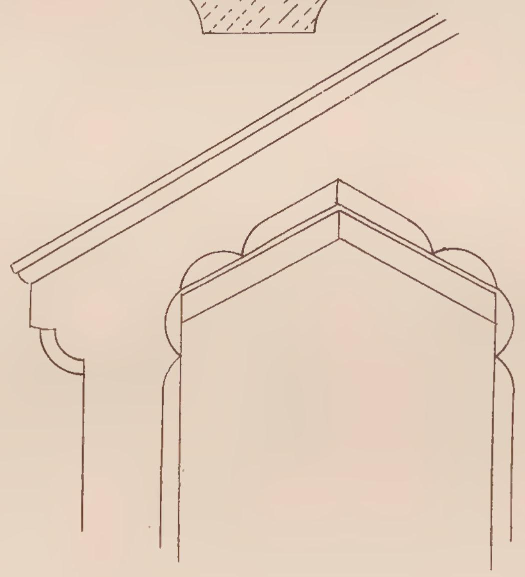
ENLARGED VIEW OF G. FIG. 7.



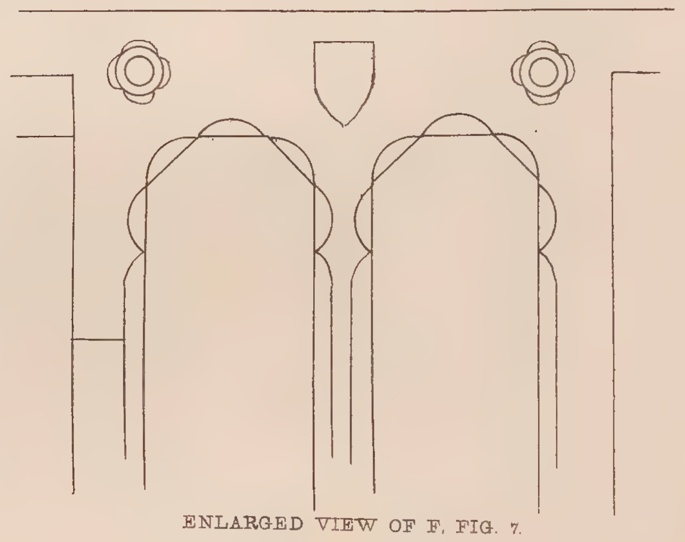
ENLARGED VIEW OF PART B IN FIG. 2.



ENLARGED VIEW OF D IN FIG. 6.

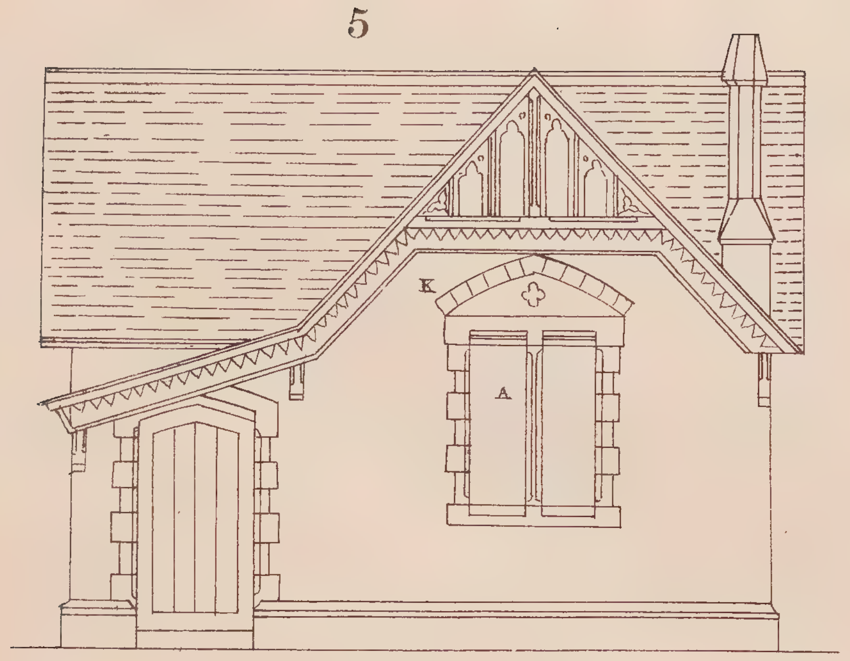


ENLARGED VIEW OF E, FIG. 7.



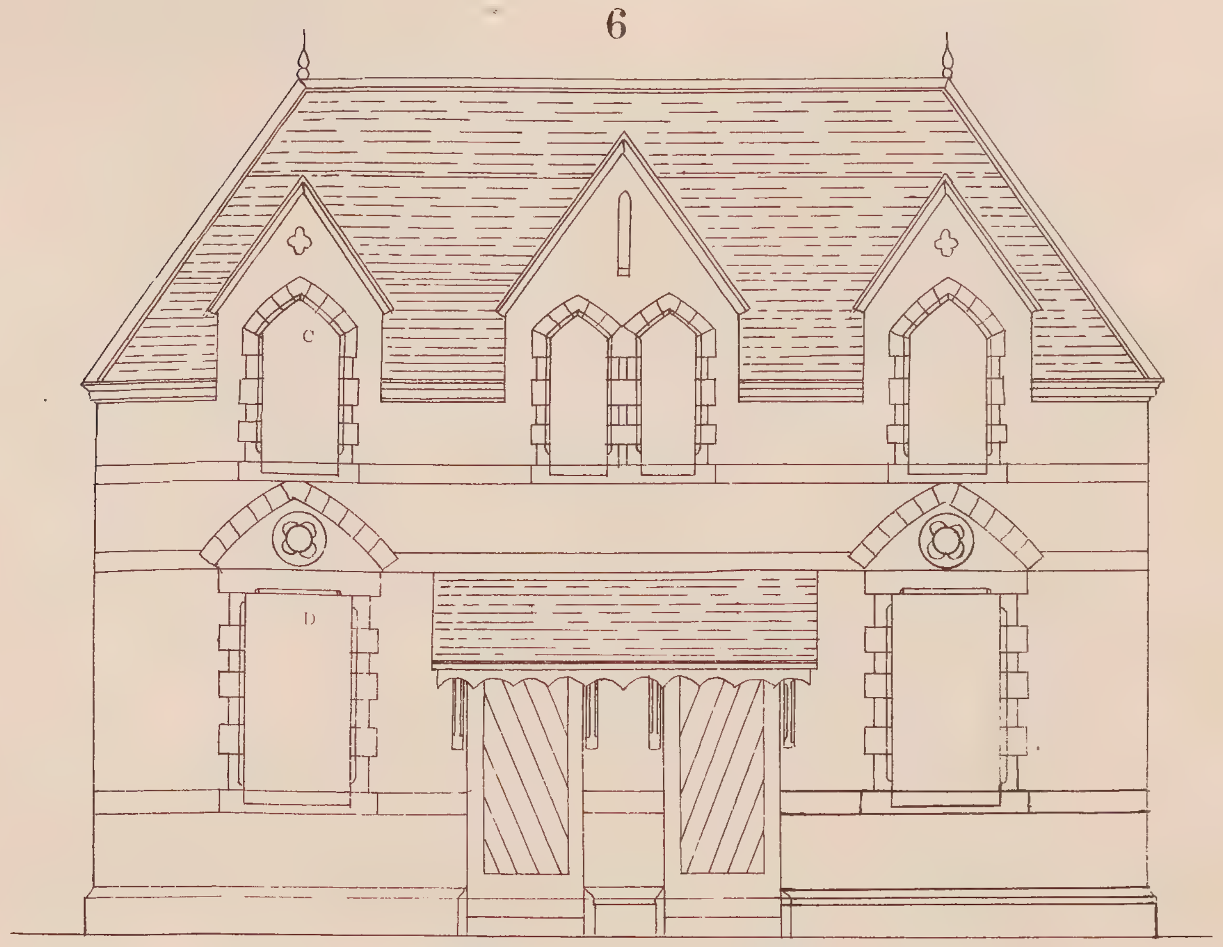
ENLARGED VIEW OF F, FIG. 7.

5



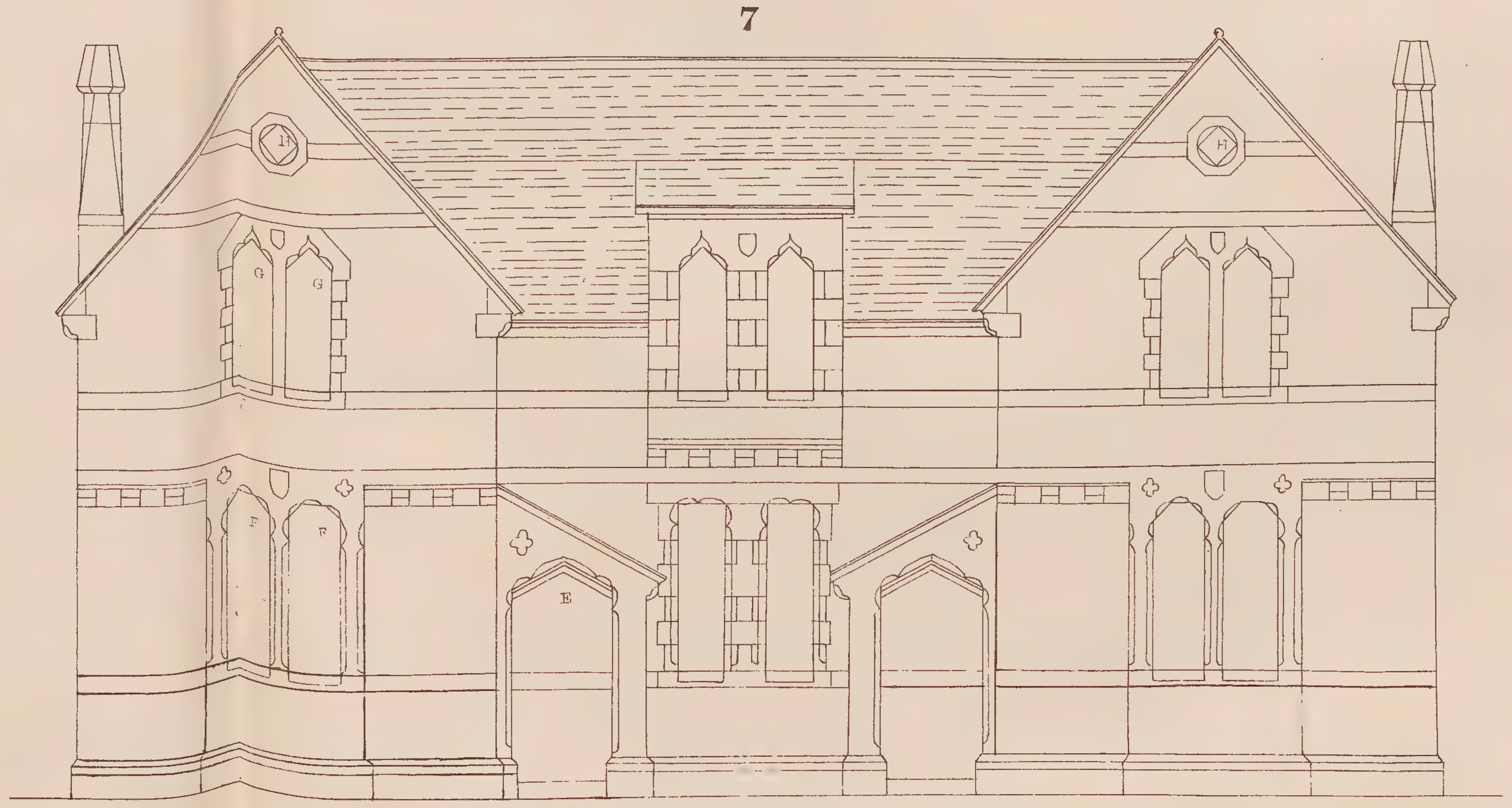
FRONT ELEVATION OF COTTAGE
Plan in fig. 4, par. 20, p. 6 Essay First.

6



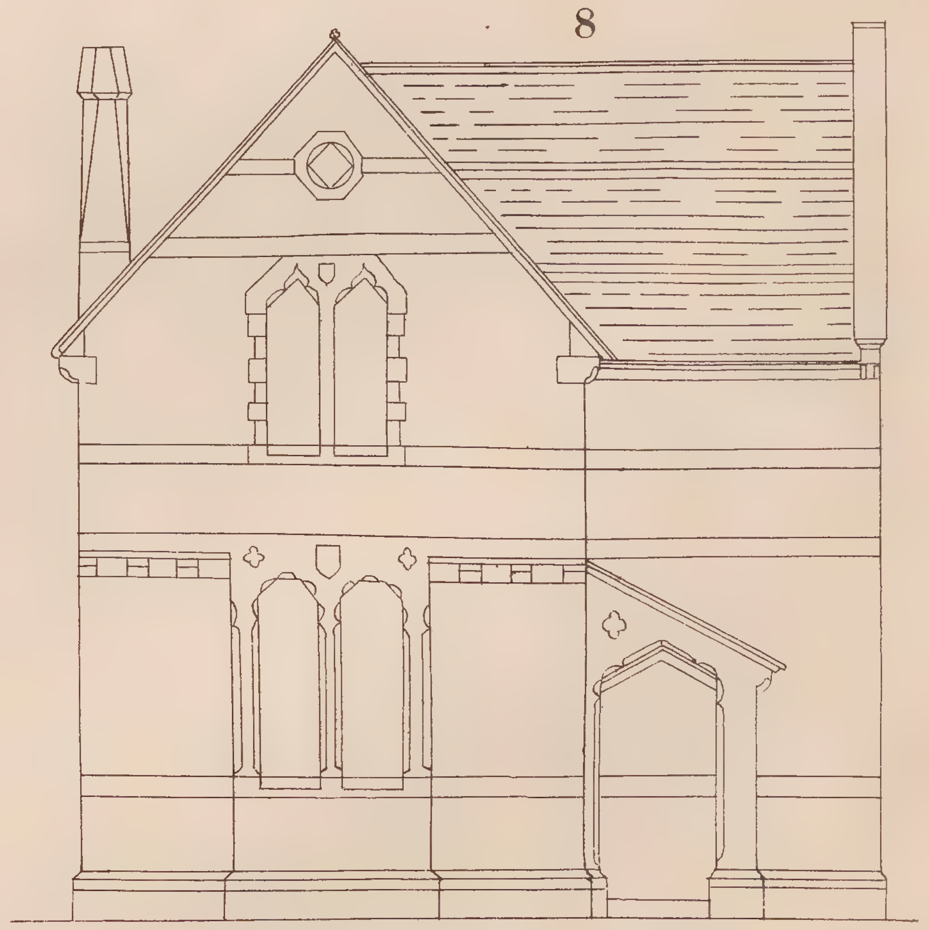
FRONT ELEVATION OF COTTAGES.
Plans in figs. 13 and 14, par. 29, p. 8, Essay First.

7



FRONT ELEVATION OF COTTAGE SHOWN AS SEMI-DETACHED.
Plans in figs. 7 and 8, par. 26, p. 7, Essay First.

8

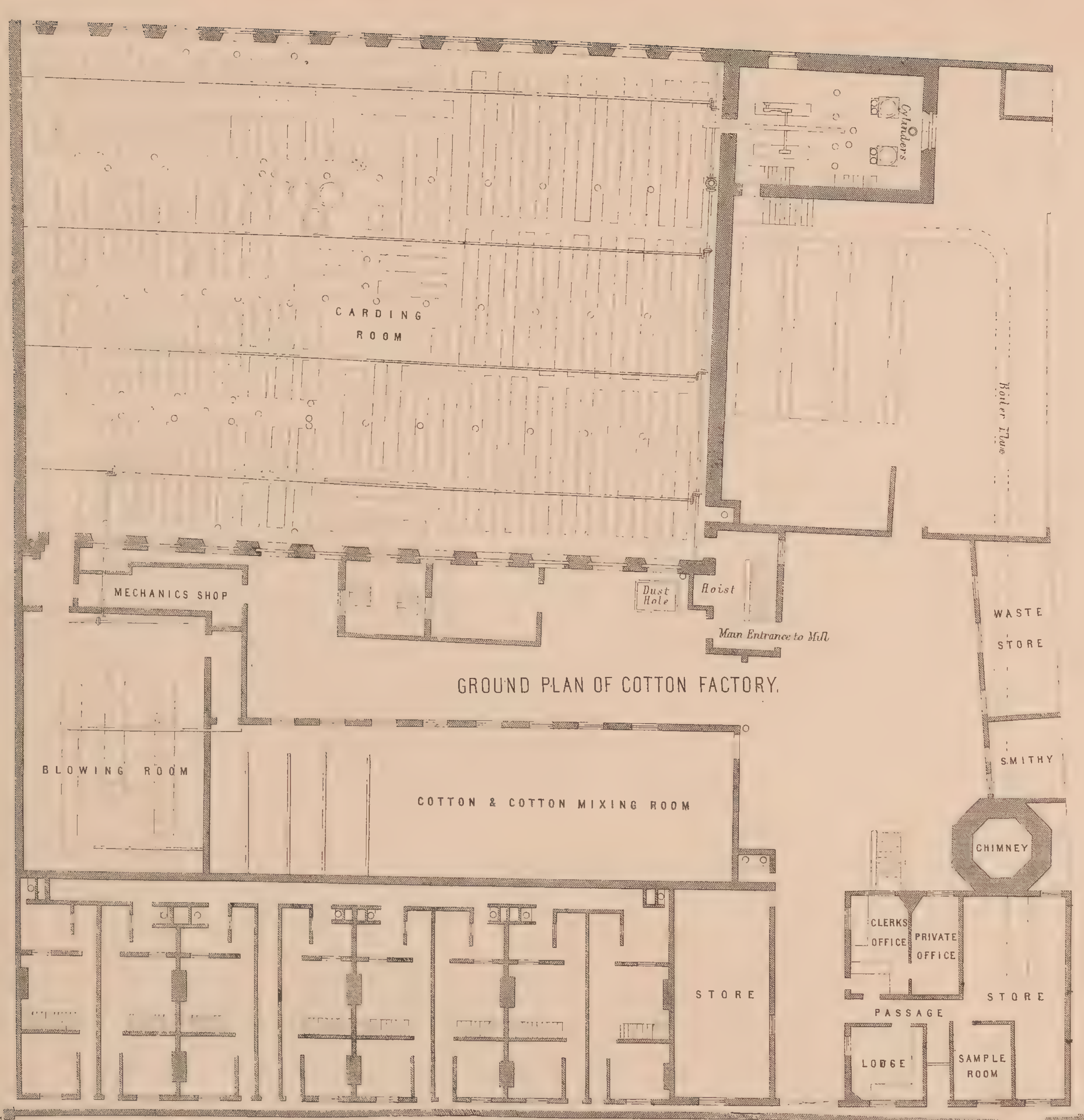


FRONT ELEVATION OF COTTAGE DETACHED.
Plans in figs. 7 and 8, par. 26, p. 7, Essay First.

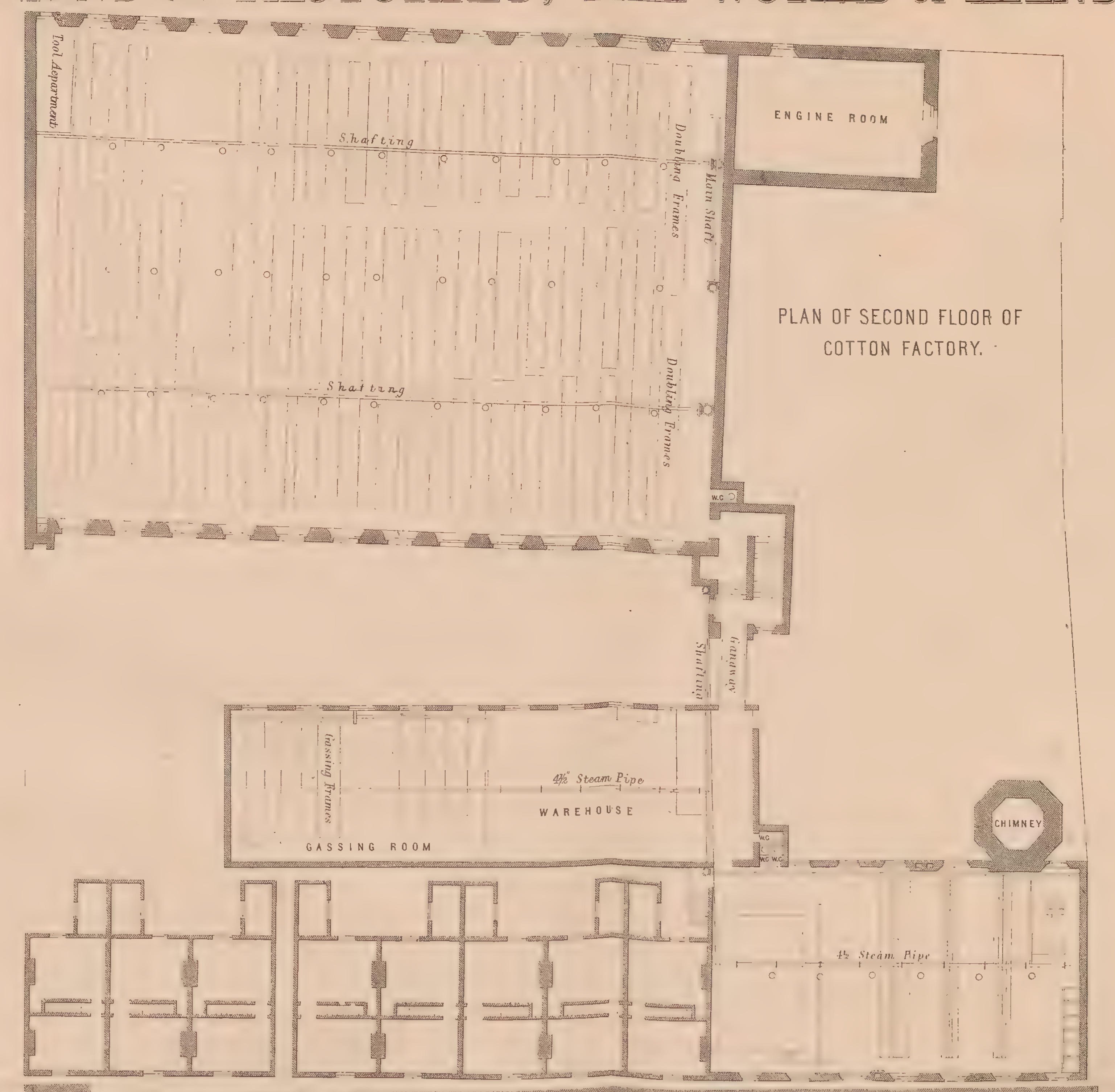
A. FULLARTON & Co. EDINBURGH, LONDON & DUBLIN

PLANS OF FACTORIES, TILE WORKS & KILNS.

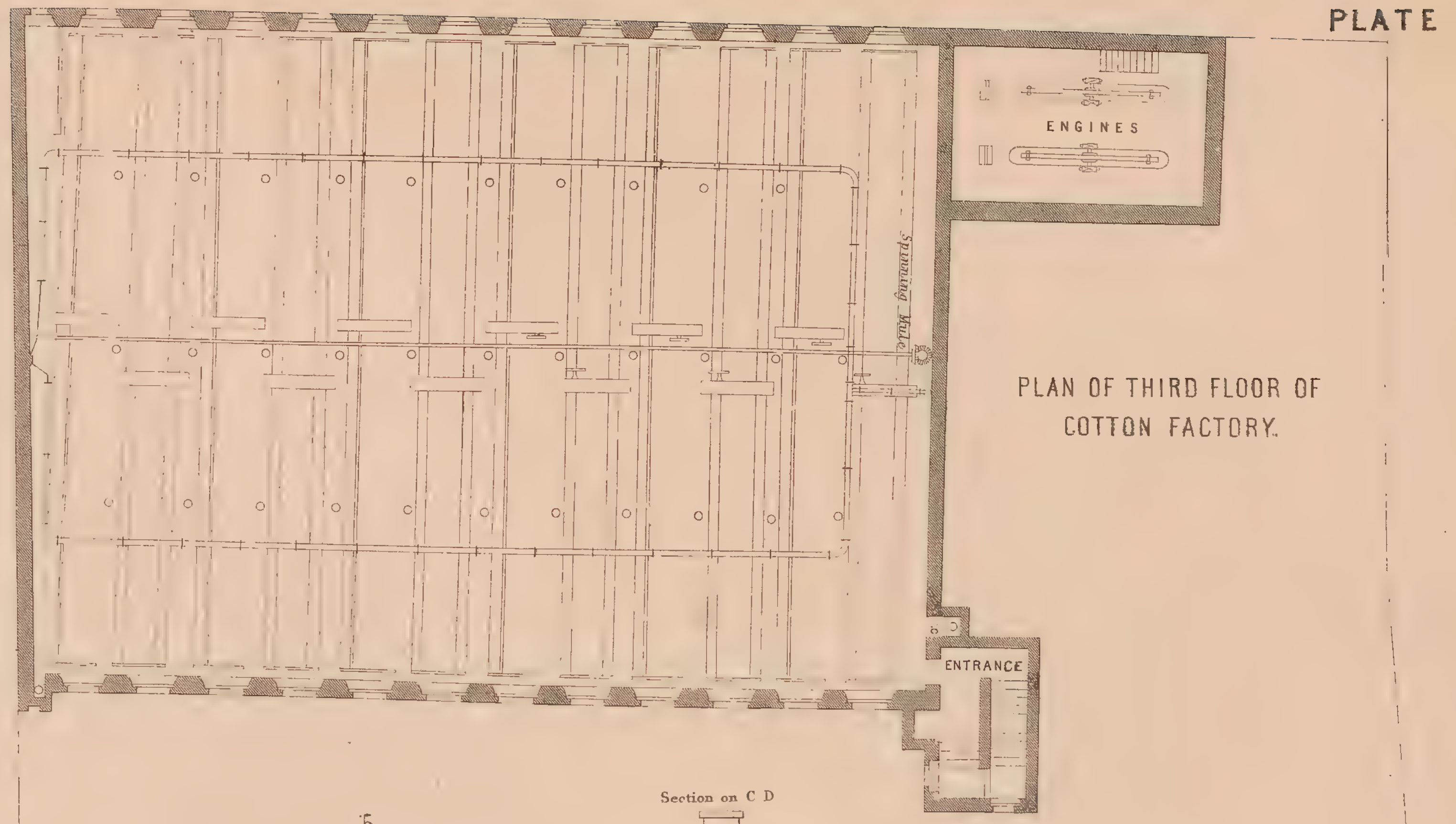
PLATE VII


CARDING ROOM
Cylinders
Boiler Flue
MECHANICS SHOP
Dust Hole
Hoist
Main Entrance to Mill
WASTE STORE
SMITHY
BLOWING ROOM
COTTON & COTTON MIXING ROOM
CHIMNEY
STORE
CLERKS OFFICE
PRIVATE OFFICE
STORE
PASSAGE
LODGE
SAMPLE ROOM

GROUND PLAN OF COTTON FACTORY.


Tool Apartment
Shafting
Doubling Frames
Main Shaft
Shafting
Doubling Frames
ENGINE ROOM
W.C
Gangway
Shafting
Gassing Frames
4½" Steam Pipe
WAREHOUSE
GASSING ROOM
W.C
CHIMNEY
4½ Steam Pipe

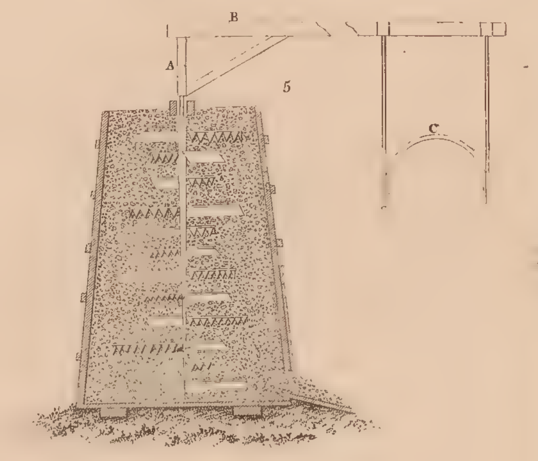
PLAN OF SECOND FLOOR OF COTTON FACTORY.

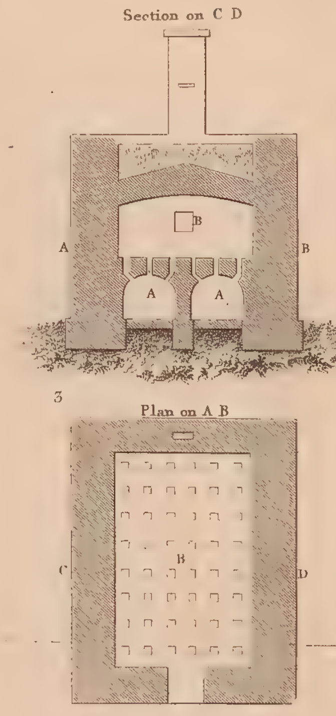

ENGINES
Spinning Mules
ENTRANCE

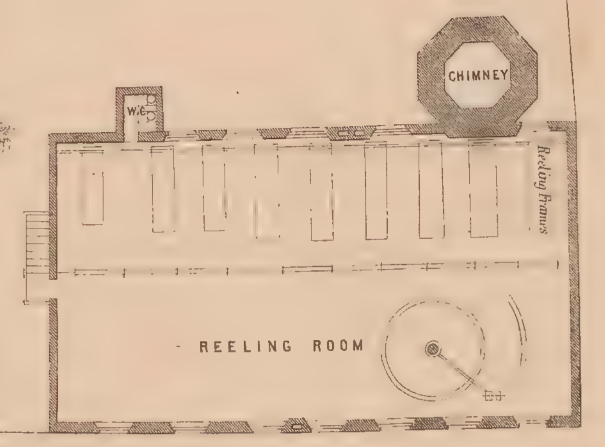
PLAN OF THIRD FLOOR OF COTTON FACTORY.

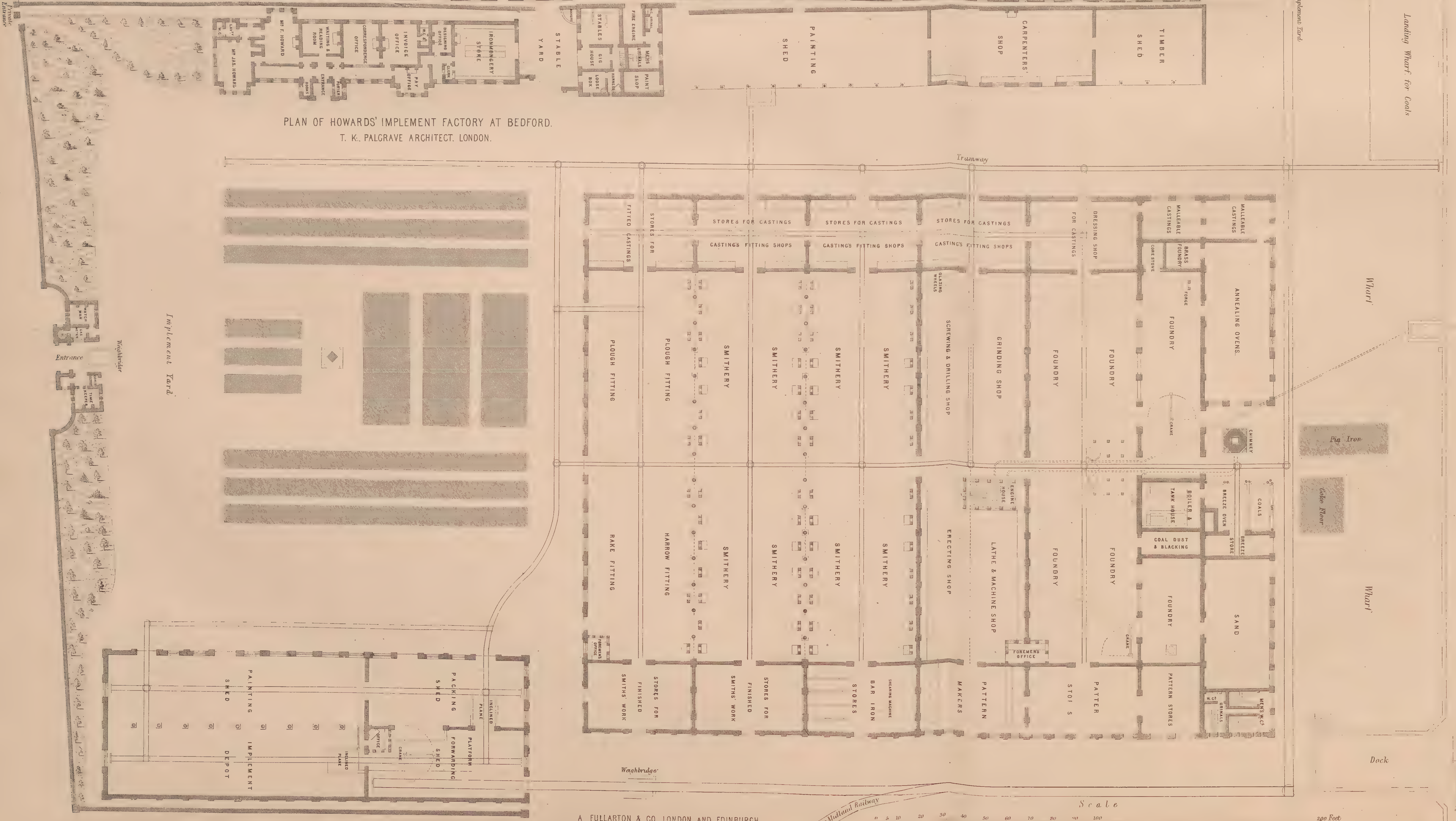
5

SECTION OF MORTAR MILL




Section on C D
A
B
A
A
3
Plan on A B
C
B
D


W.C
CHIMNEY
Reeling Frames
REELING ROOM

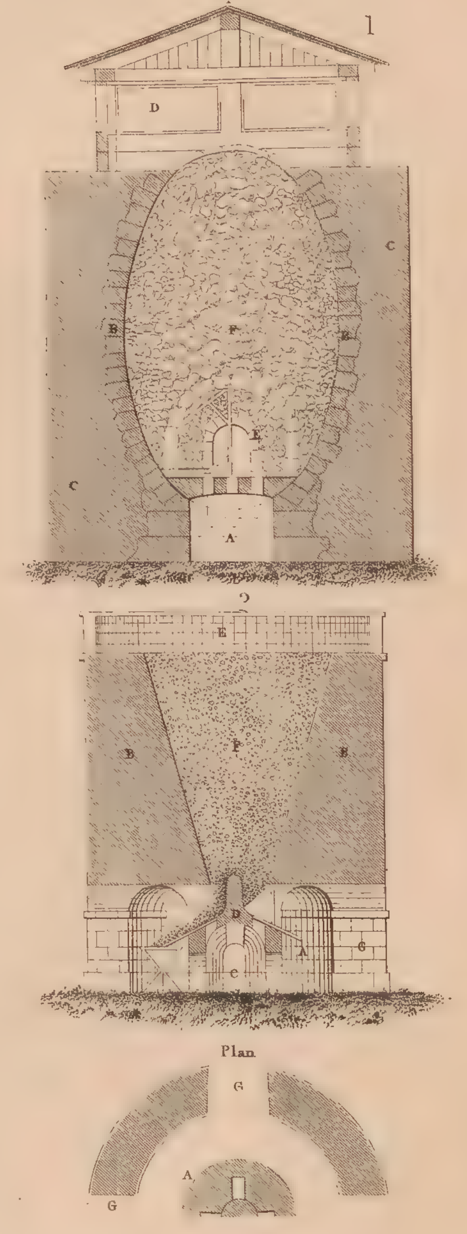

Private Entrance
Lavy
W.C
Mr JAS. HOWARD
Mr F. HOWARD
WAITING & READING ROOM
CORRESPONDENCE OFFICE
BOOKS
ENTRANCE
PORTER
INVOICE OFFICE
W.C &c
PAY OFFICE
DESIGNING OFFICE
CLERK
IRONMONGERY STORE
STABLE YARD
MANURE
STABLES
GIG HOUSE
LOOSE BOX
HARNESS
FIRE ENGINE
W.C. URINAL
MENS URINALS
PAINT SHOP
PAINTING SHED
CARPENTERS' SHOP
TIMBER SHED
From Implement Yard
Landing Wharf for Coals
Tramway
Watch Man
Gas Meter
Entrance
Coals
Time Keeper
Weighbridge
Implement Yard
FITTED CASTINGS
STORES FOR
STORES FOR CASTINGS
STORES FOR CASTINGS
STORES FOR CASTINGS
CASTINGS FITTING SHOPS
CASTINGS FITTING SHOPS
CASTINGS FITTING SHOPS
FOR CASTINGS
DRESSING SHOP
MALLEABLE CASTINGS
MALLEABLE CASTINGS
CORE STOVE
BRASS FOUNDRY
FORGE
GLAZING WHEELS
PLOUGH FITTING
PLOUGH FITTING
SMITHERY
SMITHERY
SMITHERY
SMITHERY
SCREWING & DRILLING SHOP
GRINDING SHOP
FOUNDRY
FOUNDRY
FOUNDRY
ANNEALING OVENS.
CRANE
CHIMNEY
Wharf
Pig Iron
Coke Floor
ENGINE HOUSE
BOILER & TANK HOUSE
BREEZE OVEN
COALS
COAL DUST & BLACKING
STORE
BREEZE
RAKE FITTING
HARROW FITTING
SMITHERY
SMITHERY
SMITHERY
SMITHERY
ERECTING SHOP
LATHE & MACHINE SHOP
FOUNDRY
FOUNDRY
FOUNDRY
SAND
CRANE
FOREMENS OFFICE
FOREMENS OFFICE
SMITHS' WORK
FINISHED
STORES FOR
SMITHS' WORK
FINISHED
STORES FOR
STORES
BAR IRON
SHEARING MACHINE
MAKERS
PATTERN
STOF S
PATTER
PATTERN STORES
W.Cs
URINALS
MEN'S W.Cs
Wharf
Dock
PAINTING SHED
IMPLEMENT DEPOT
OFFICE
INCLINED PLANE
CRANE
PACKING SHED
INCLINED PLANE
PLATFORM
FORWARDING SHED
Weighbridge
Siding from Midland Railway

PLAN OF HOWARDS' IMPLEMENT FACTORY AT BEDFORD.
T. K. PALGRAVE ARCHITECT. LONDON.

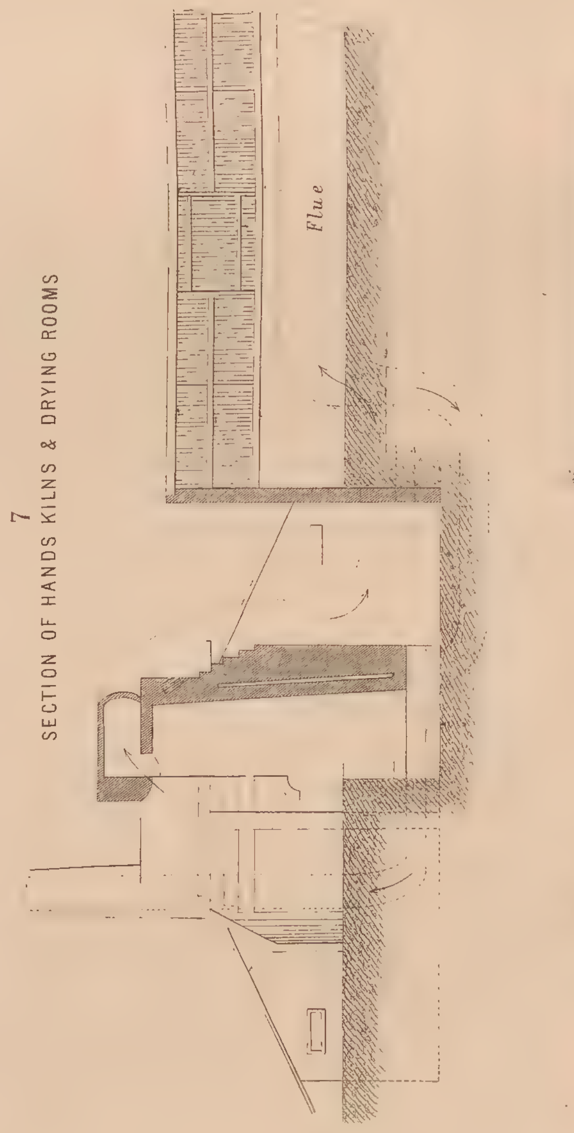
Scale

0 5 10 20 30 40 50 60 70 80 90 100 200 Feet

PLAN AND SECTION OF LIME KILN

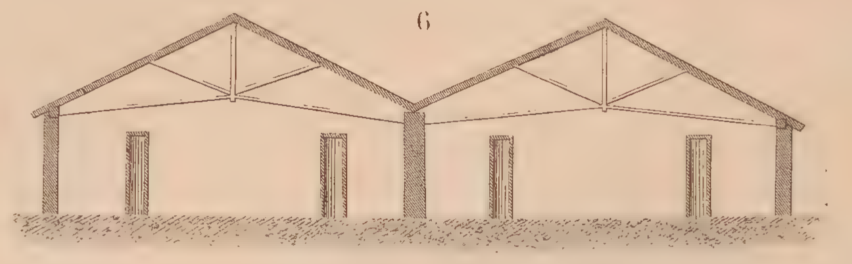

1
D
C
B
A
2
Plan
A

7
SECTION OF HANDS KILNS & DRYING ROOMS



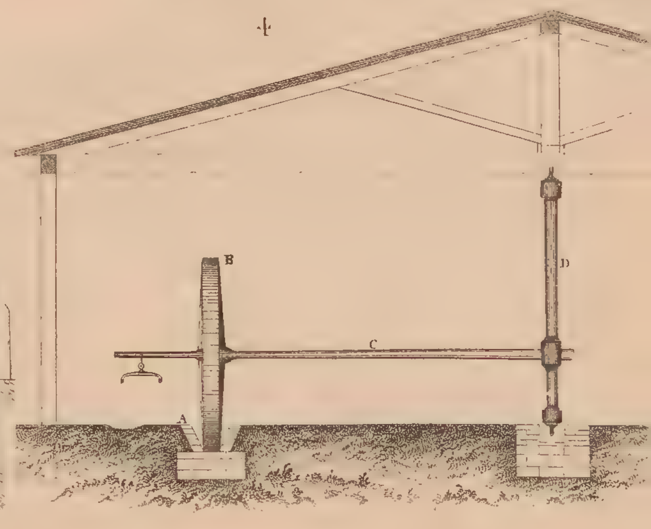
SECTION OF HANDS DRYING ROOM

6

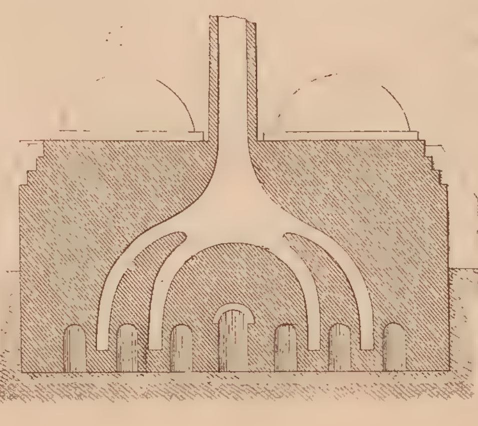


MORTAR MILL

4



SECTION OF HANDS BRICK KILN



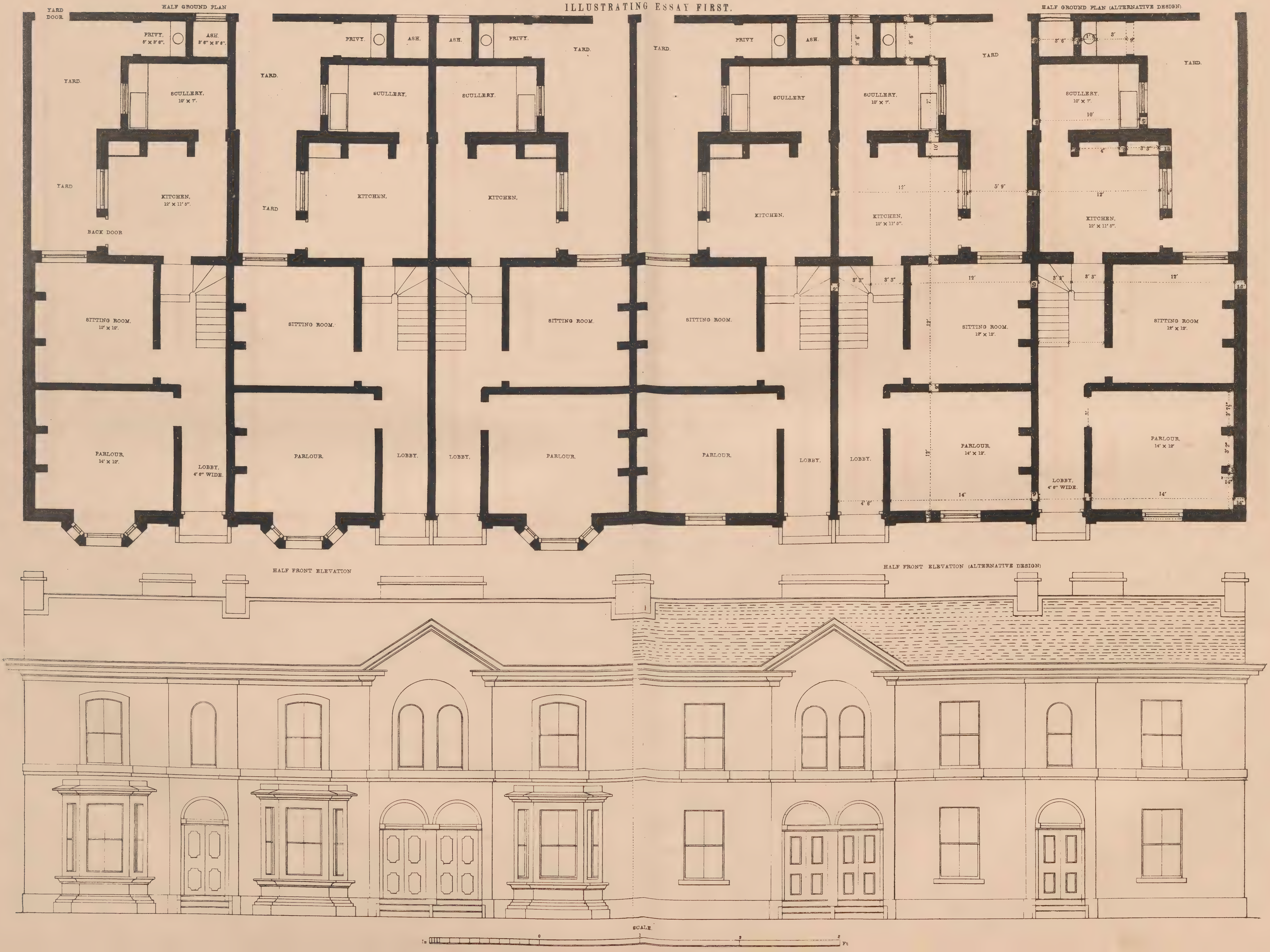
A FULLARTON & CO. LONDON AND EDINBURGH.

Engraved by J. Bartholomew Edinburgh.

FIRST-CLASS COTTAGES ADAPTED TO MANUFACTURING AND TOWN DISTRICTS.

PLATE IX

ILLUSTRATING ESSAY FIRST.


HALF GROUND PLAN
YARD DOOR
PRIVY, 5' × 3' 6".
ASH. 3' 6" × 3' 6".
YARD.
SCULLERY, 10' × 7'.
YARD
KITCHEN, 12' × 11' 5".
BACK DOOR
SITTING ROOM. 12' × 12'.
PARLOUR, 14' × 12'.
LOBBY, 4' 6" WIDE.
PRIVY.
ASH.
SCULLERY.
KITCHEN.
SITTING ROOM.
PARLOUR.
LOBBY.
HALF GROUND PLAN (ALTERNATIVE DESIGN).
3' 6"
1' 6"
3'
10'
4'
3' 3"
12'
5' 9"
14'
HALF FRONT ELEVATION
HALF FRONT ELEVATION (ALTERNATIVE DESIGN)
SCALE.
0
1
2
3
Ft

SECOND CLASS HOUSES ADAPTED TO MANUFACTURING & TOWN DISTRICTS, ON THE FLAT SYSTEM.

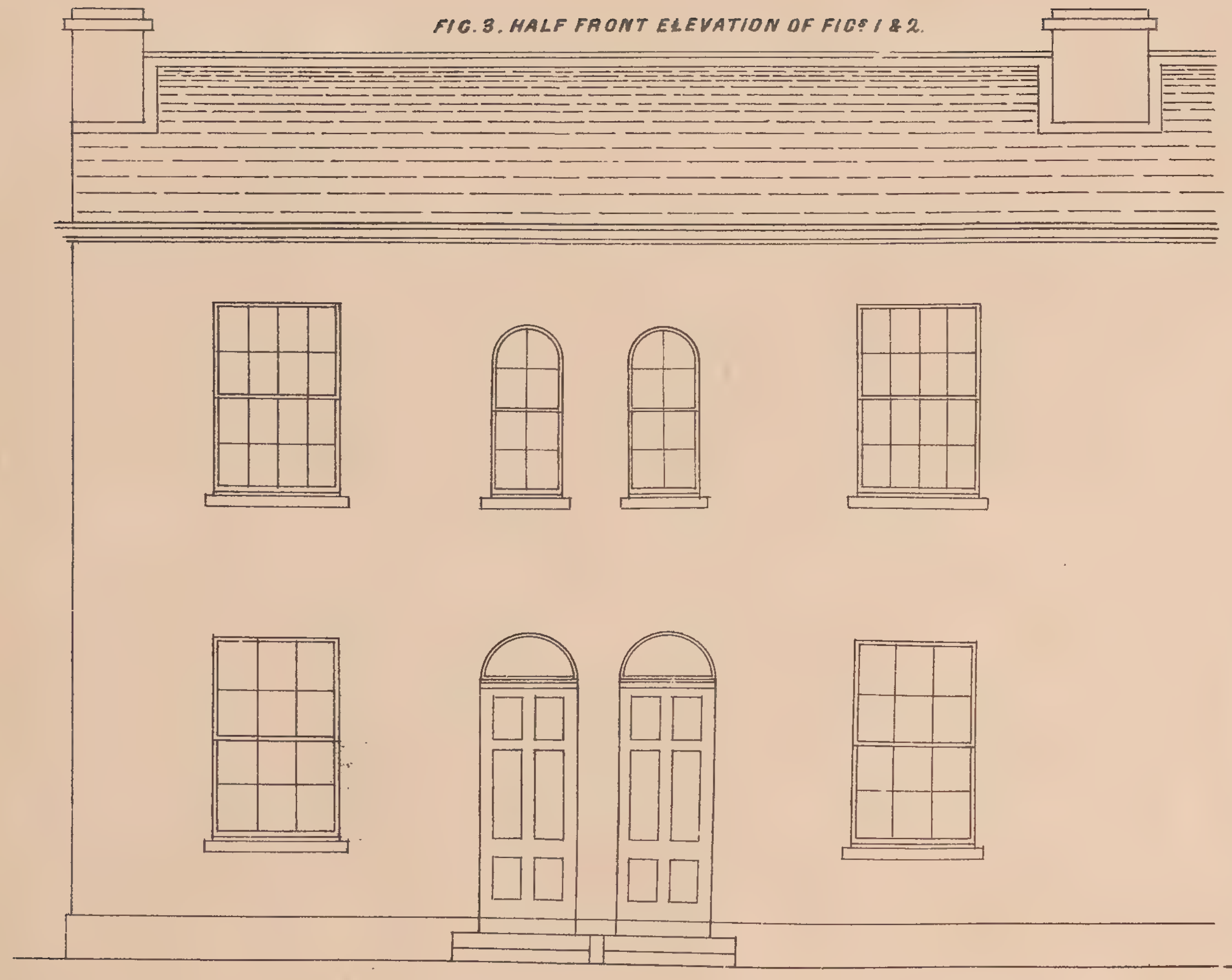
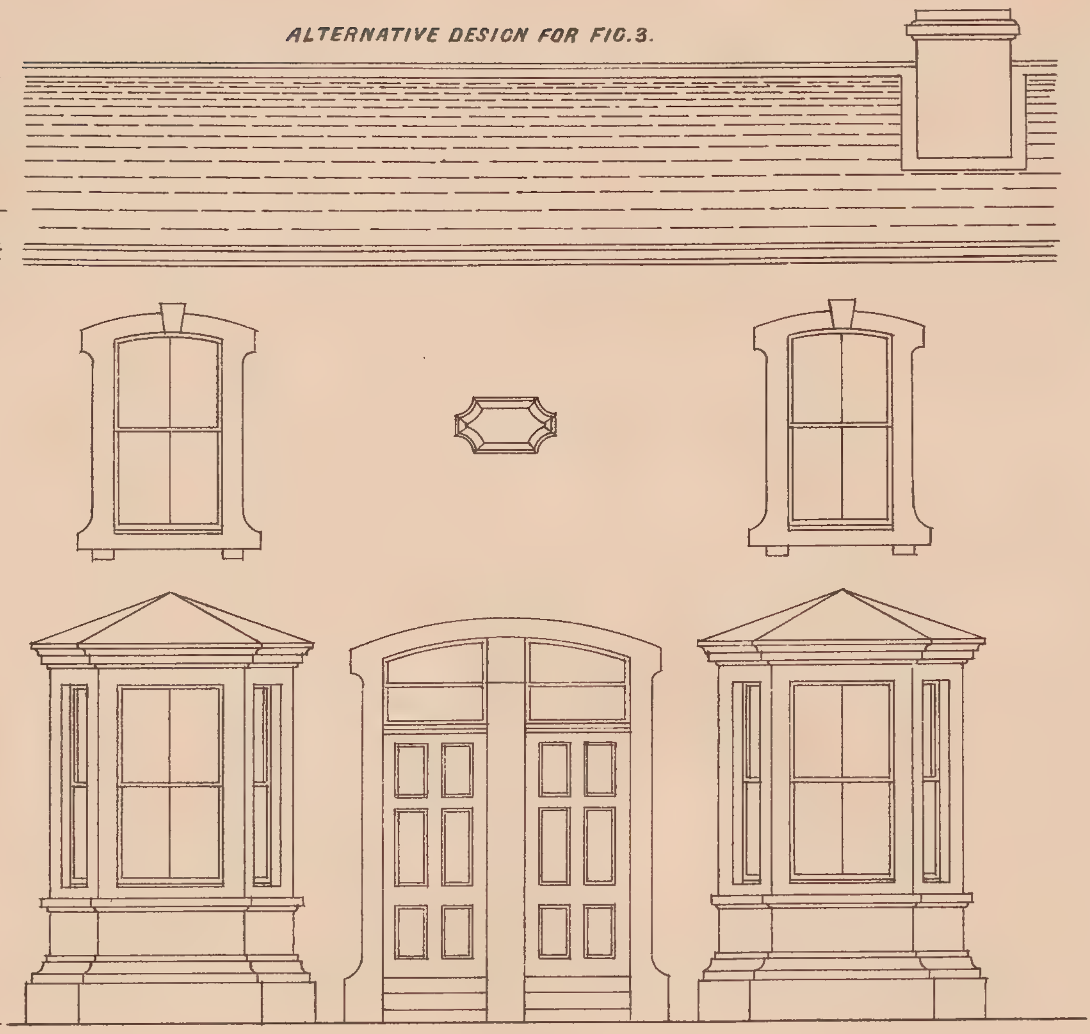


FIG. 3. HALF FRONT ELEVATION OF FIGS 1 & 2.



ALTERNATIVE DESIGN FOR FIG. 3.

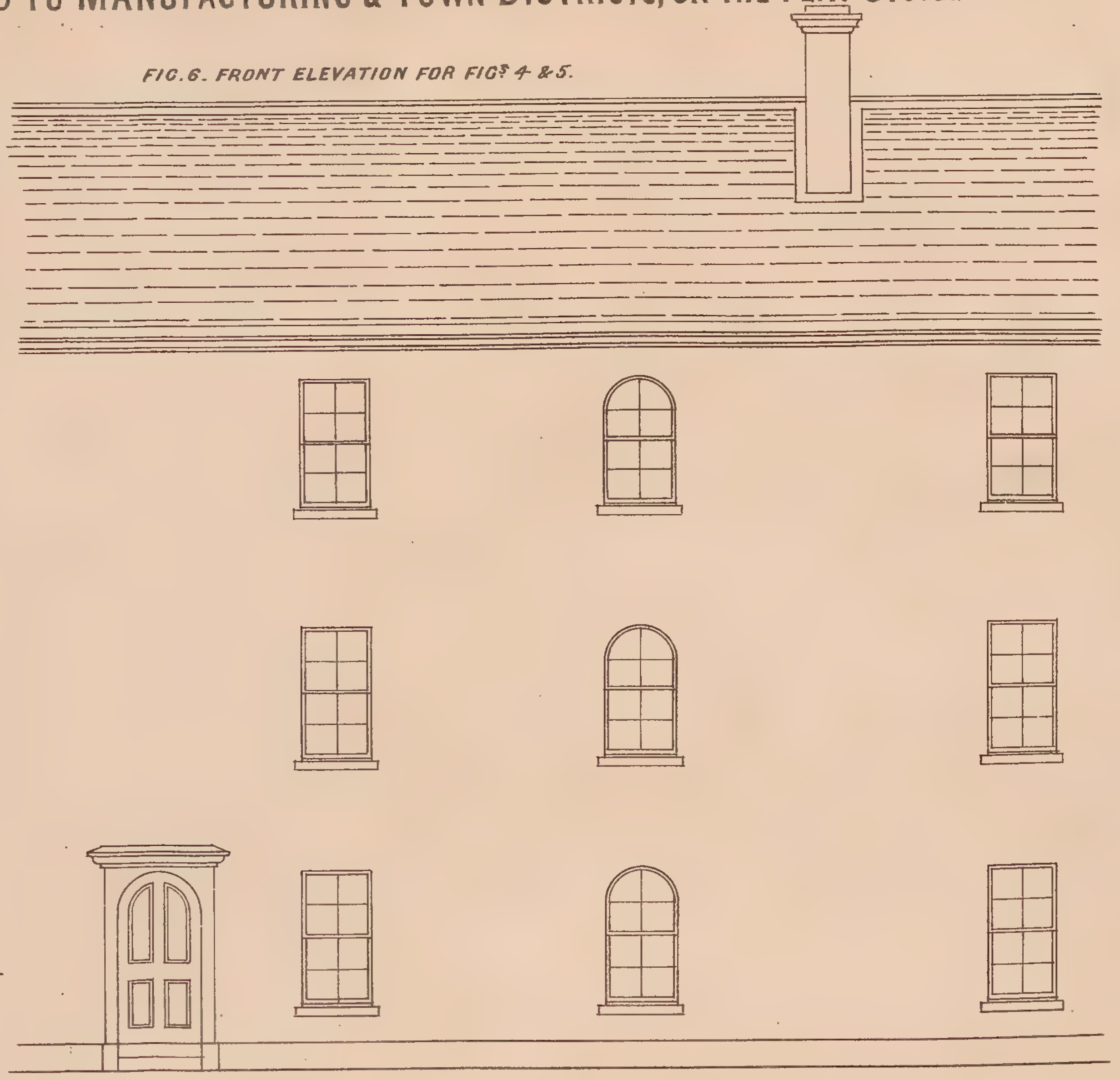
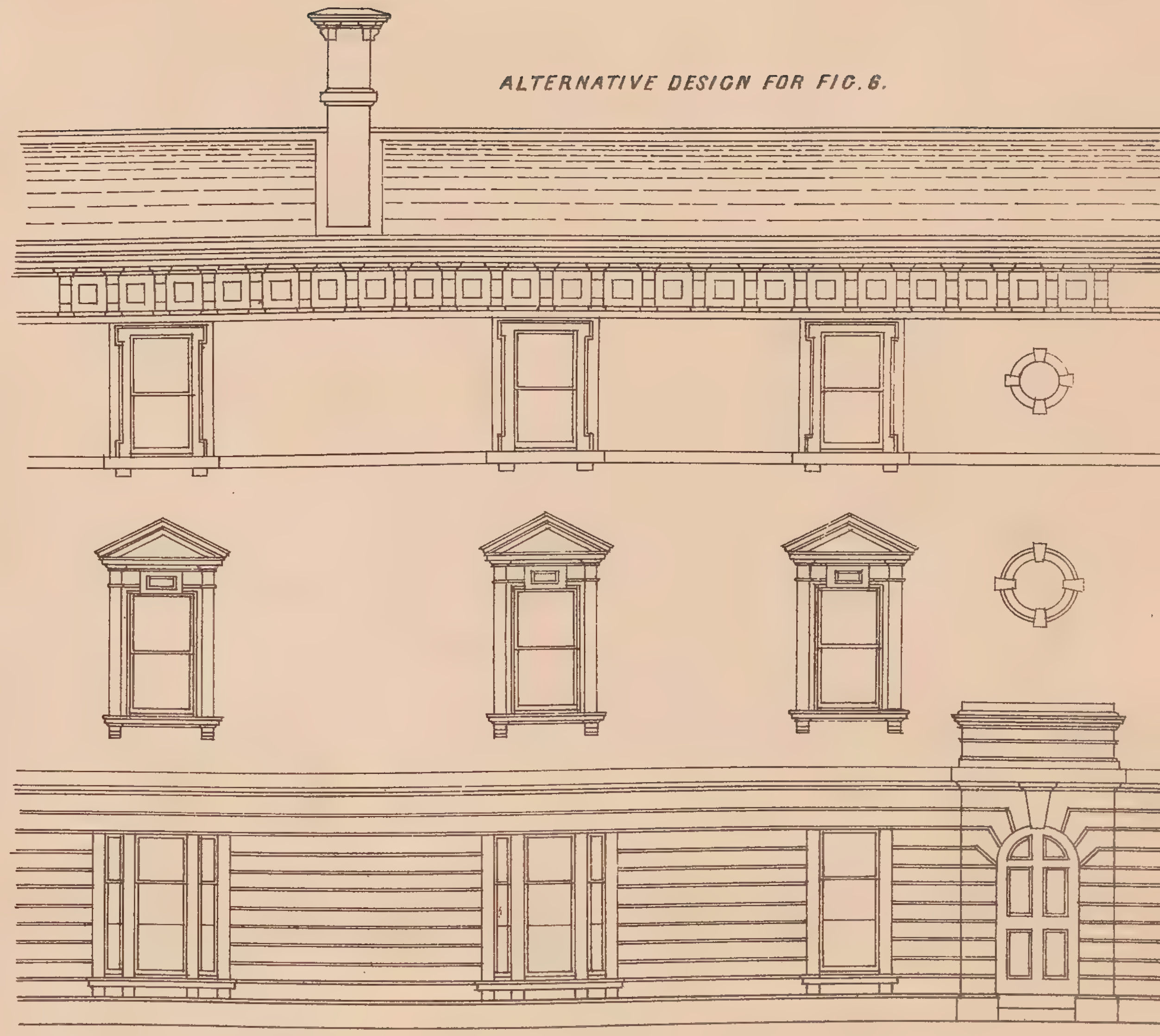


FIG. 6. FRONT ELEVATION FOR FIGS 4 & 5.



ALTERNATIVE DESIGN FOR FIG. 6.

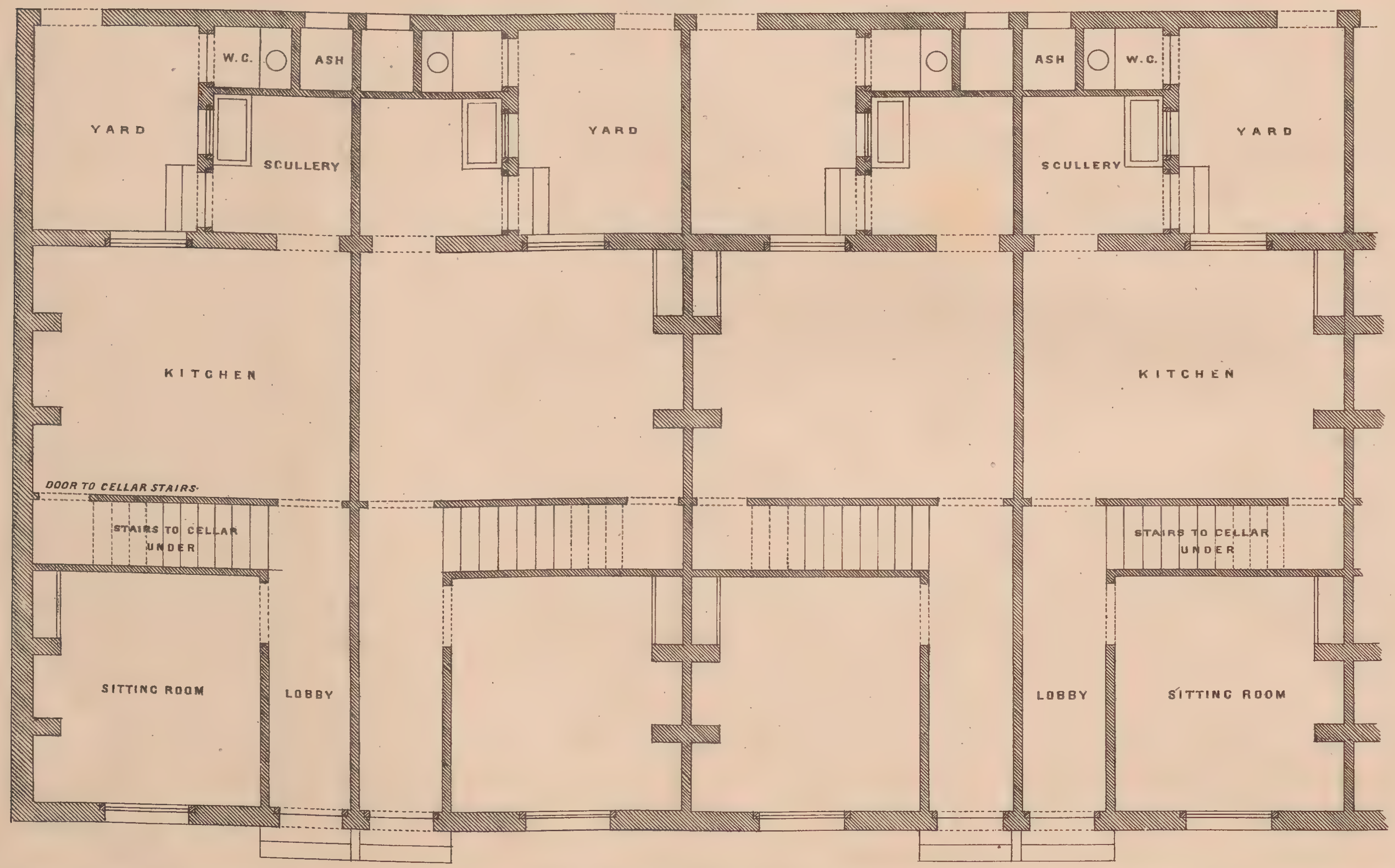


FIG. 1. GROUND PLAN.

W.C.
ASH
ASH
W.C.
YARD
SCULLERY
YARD
SCULLERY
YARD
KITCHEN
KITCHEN
DOOR TO CELLAR STAIRS
STAIRS TO CELLAR UNDER
STAIRS TO CELLAR UNDER
SITTING ROOM
LOBBY
LOBBY
SITTING ROOM

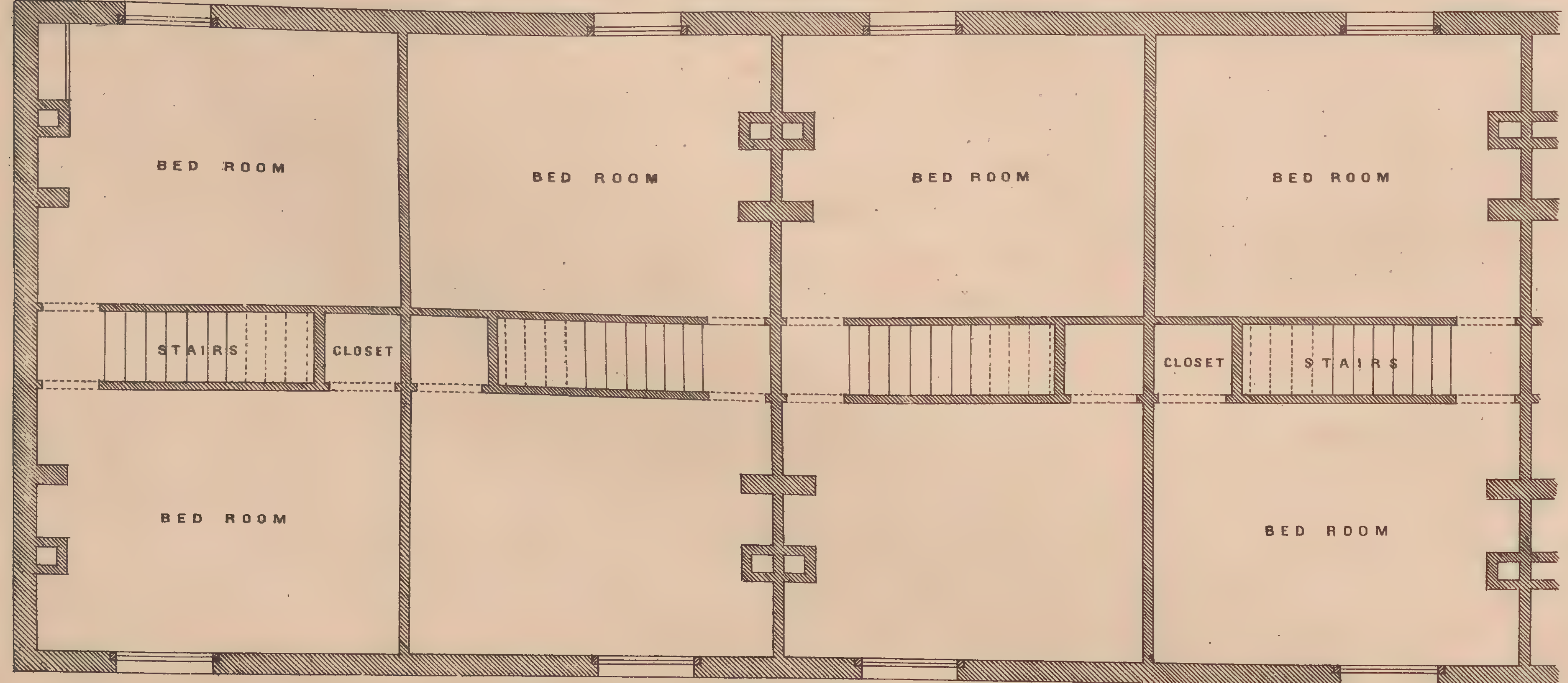


FIG. 2. HALF CHAMBER PLAN

BED ROOM
BED ROOM
BED ROOM
BED ROOM
STAIRS
CLOSET
CLOSET
STAIRS
BED ROOM
BED ROOM

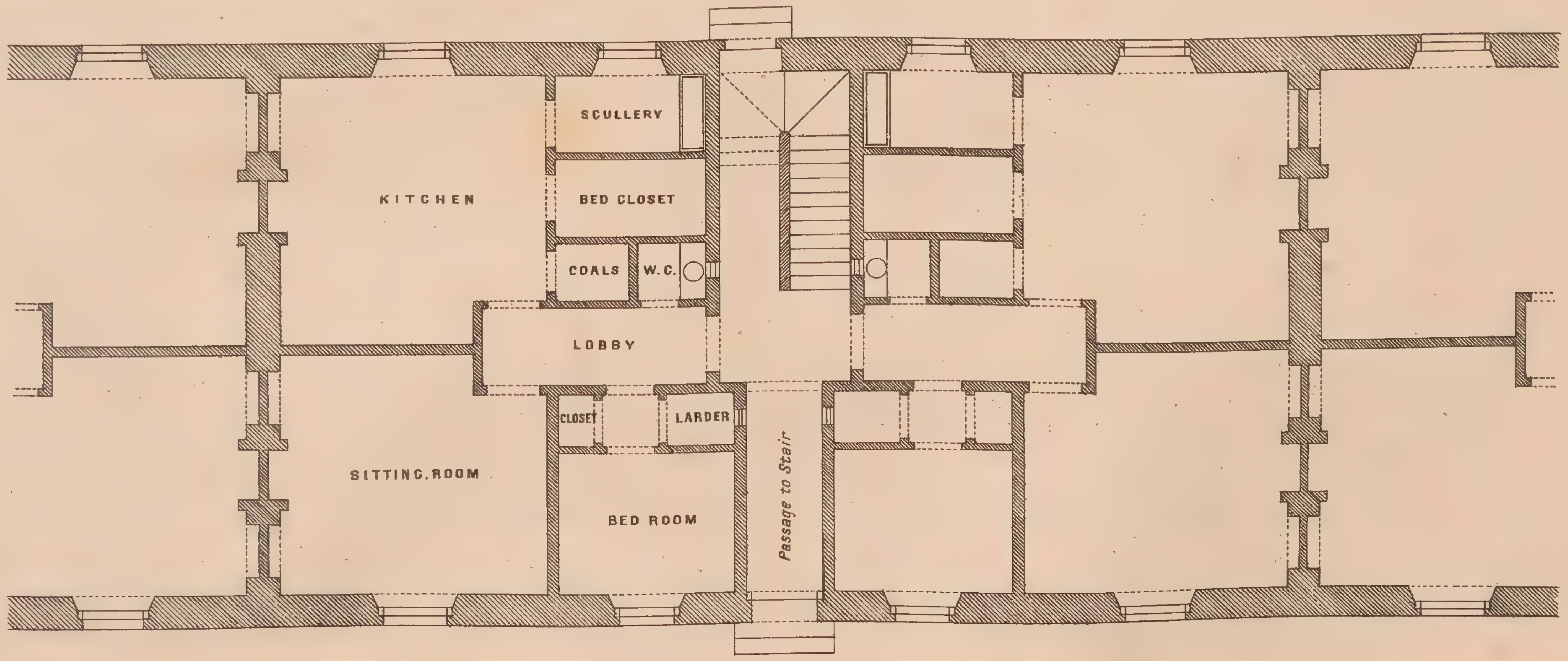


FIG. 5. GROUND PLAN.

SCULLERY
BED CLOSET
KITCHEN
COALS
W.C.
LOBBY
CLOSET
LARDER
SITTING ROOM
BED ROOM
Passage to Stair

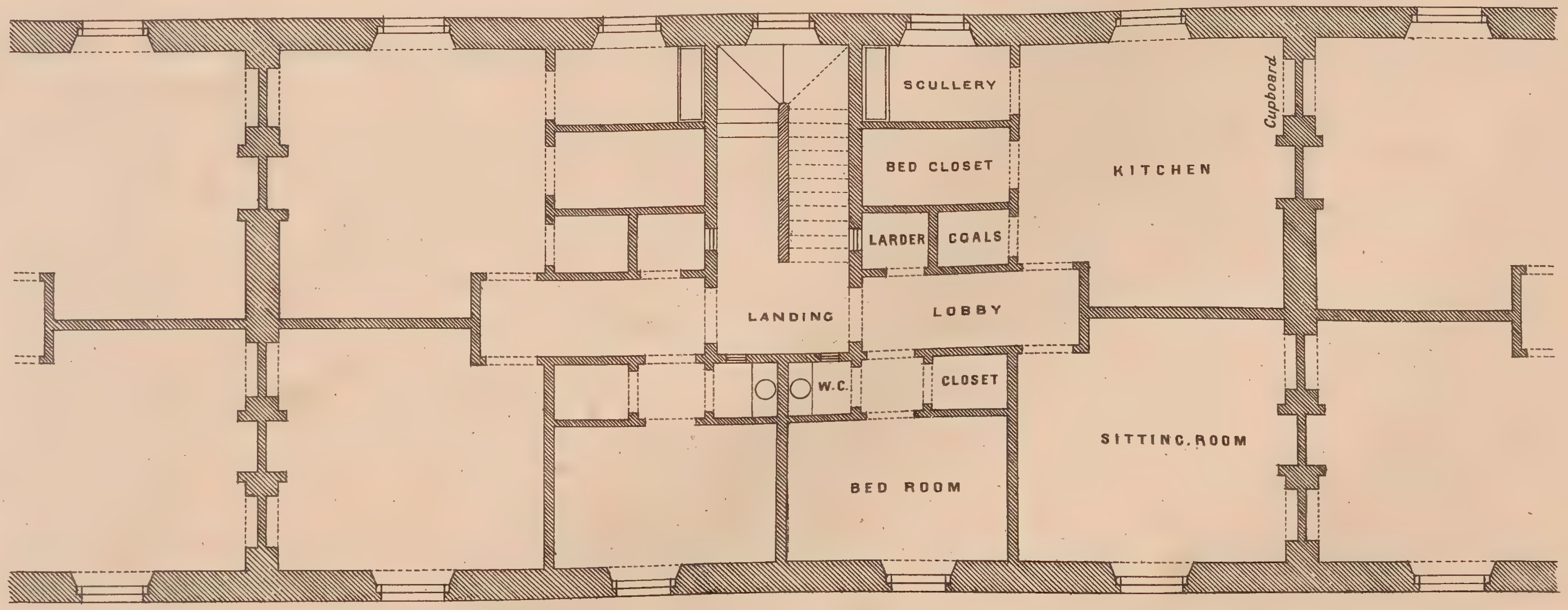
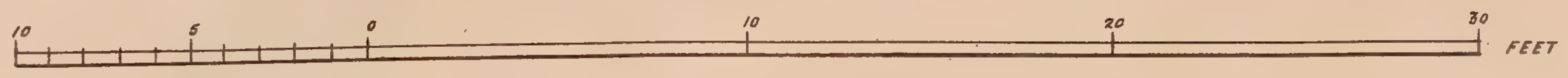


FIG. 4. PLAN OF SECOND & THIRD STORIES.

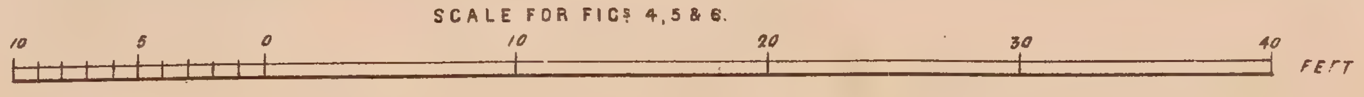
SCULLERY
BED CLOSET
KITCHEN
Cupboard
LARDER
COALS
LANDING
LOBBY
W.C.
CLOSET
SITTING ROOM
BED ROOM

SCALE FOR FIGS 1, 2 & 3.



10
5
0
10
20
30
FEET

SCALE FOR FIGS 4, 5 & 6.



10
5
0
10
20
30
40
FEET

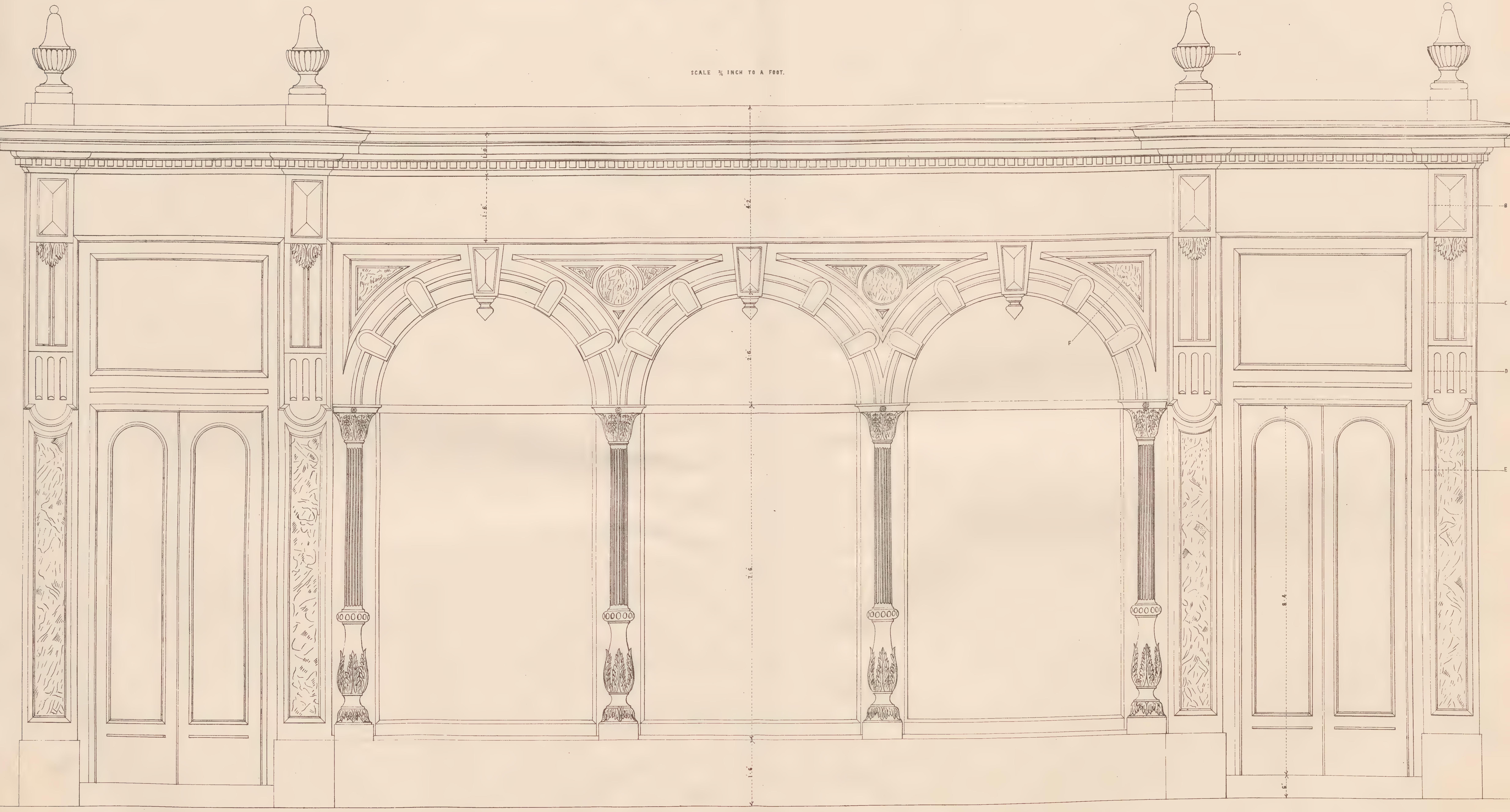
J. W. BOGUE, LITH.

A. FULLARTON & CO. LONDON AND EDINBURGH

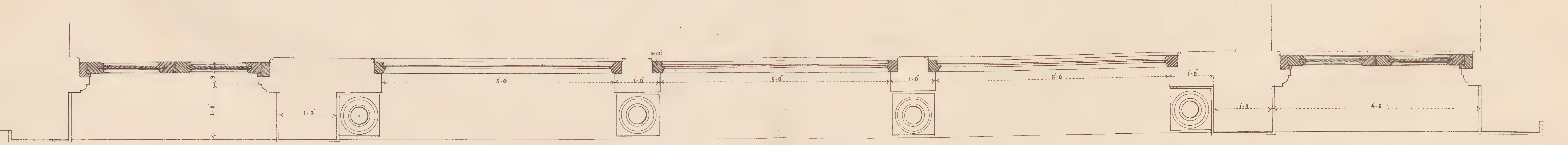
PLATE XI.

DESIGN FOR SHOP FRONT. STYLE, ITALIAN.

SCALE ¾ INCH TO A FOOT.


G
B
C
D
E
F
1'.0"
1'.6"
4'.2"
2'.6"
7'.6"
1'.6"
8'.4"
6"

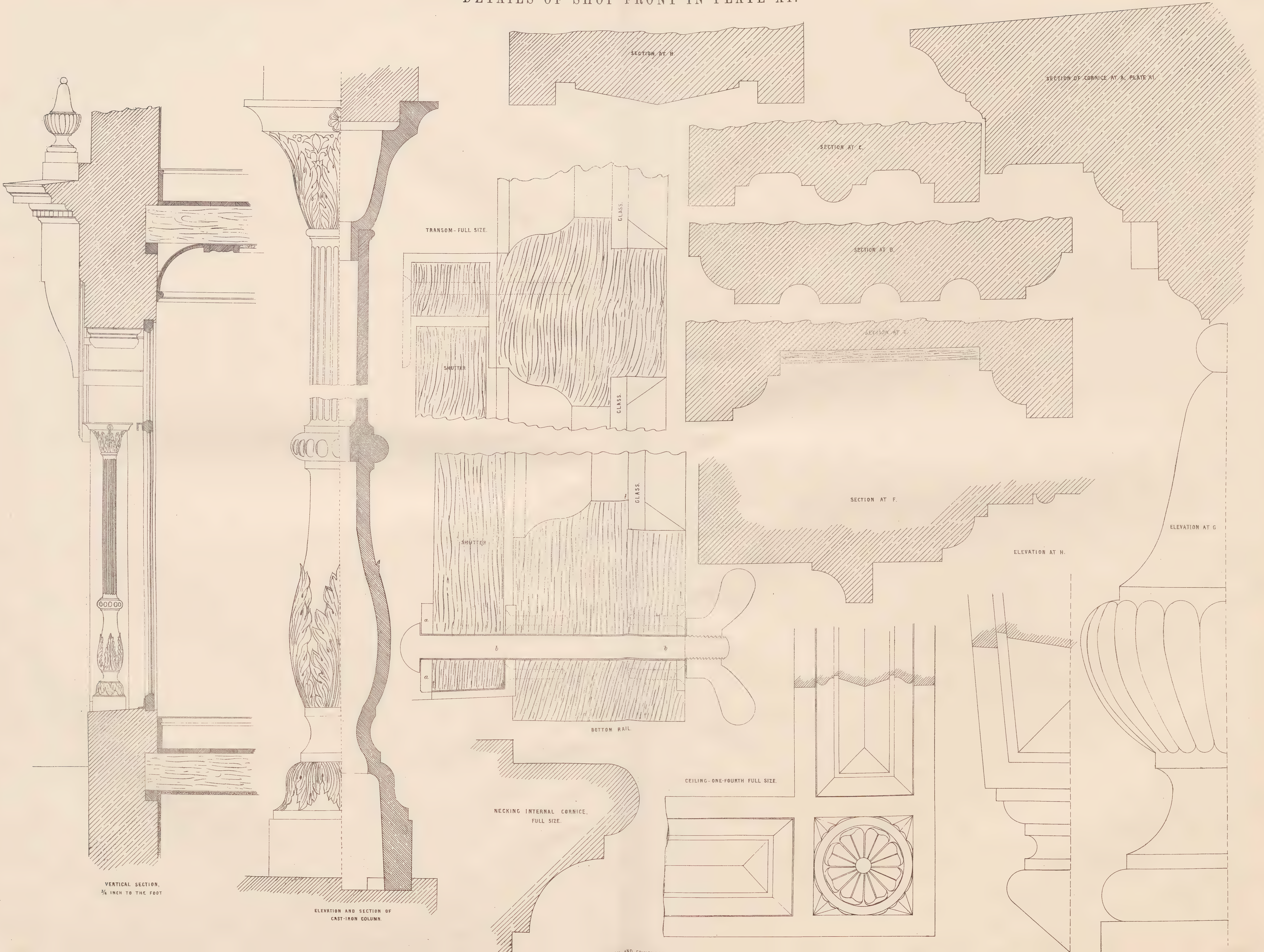
ELEVATION.


9"
1'.0"
1'.3"
5'.0"
1'.0"
3½ x 3½
5'.0"
1'.0"
5'.0"
1'.0"
1'.3"
4'.6"

PLAN.

A. FULLARTON & CO. LONDON AND EDINBURGH.

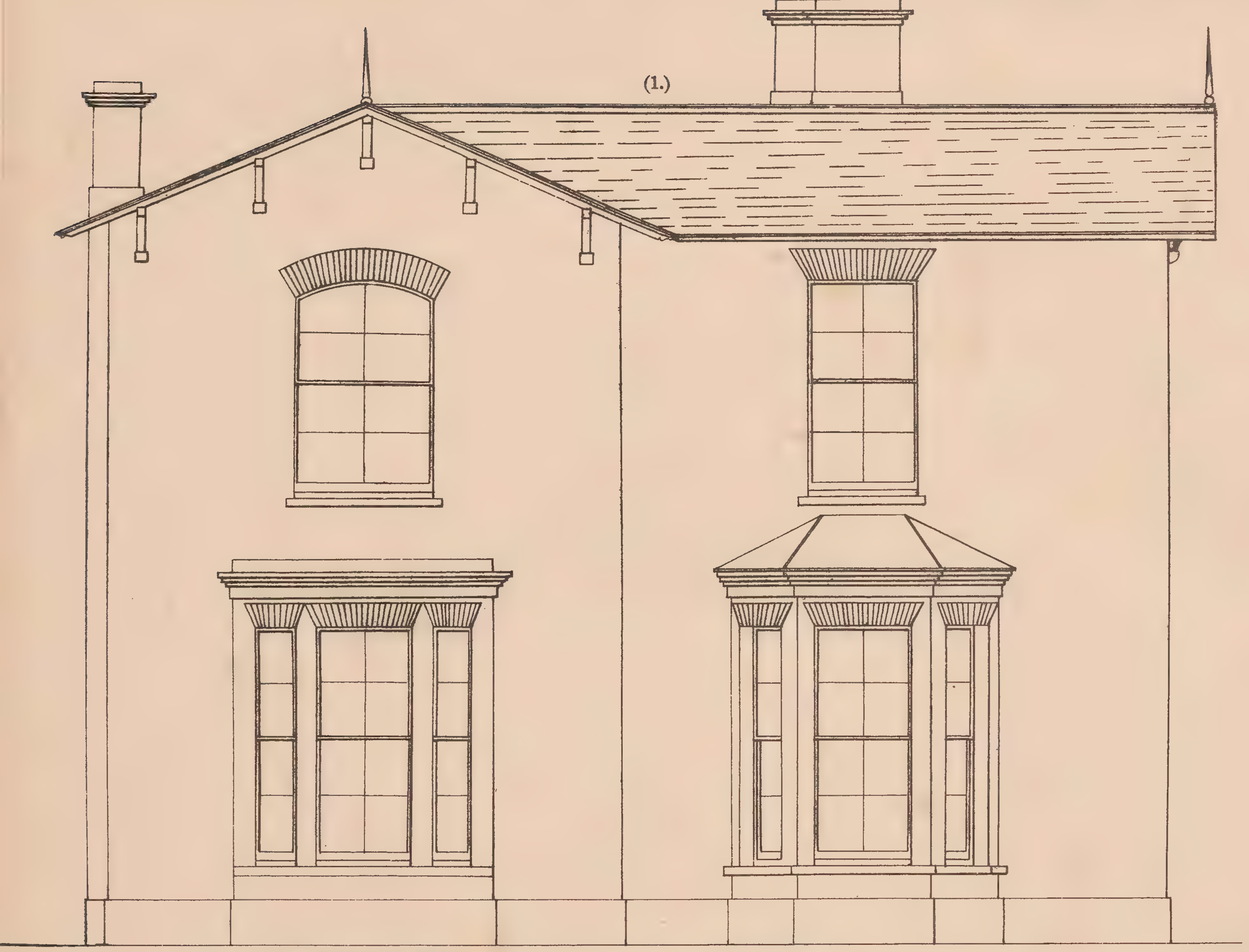
DETAILS OF SHOP FRONT IN PLATE XI.


SECTION AT B.
SECTION OF CORNICE AT A, PLATE XI.
SECTION AT C.
SECTION AT D.
SECTION AT E.
SECTION AT F.
TRANSOM—FULL SIZE.
GLASS.
GLASS.
SHUTTER
SHUTTER
GLASS.
a
a
b
b
BOTTOM RAIL.
ELEVATION AT G
ELEVATION AT H.
NECKING INTERNAL CORNICE, FULL SIZE.
CEILING—ONE-FOURTH FULL SIZE.
VERTICAL SECTION, 3/4 INCH TO THE FOOT
ELEVATION AND SECTION OF CAST-IRON COLUMN.

A. FULLARTON & CO. LONDON AND EDINBURGH

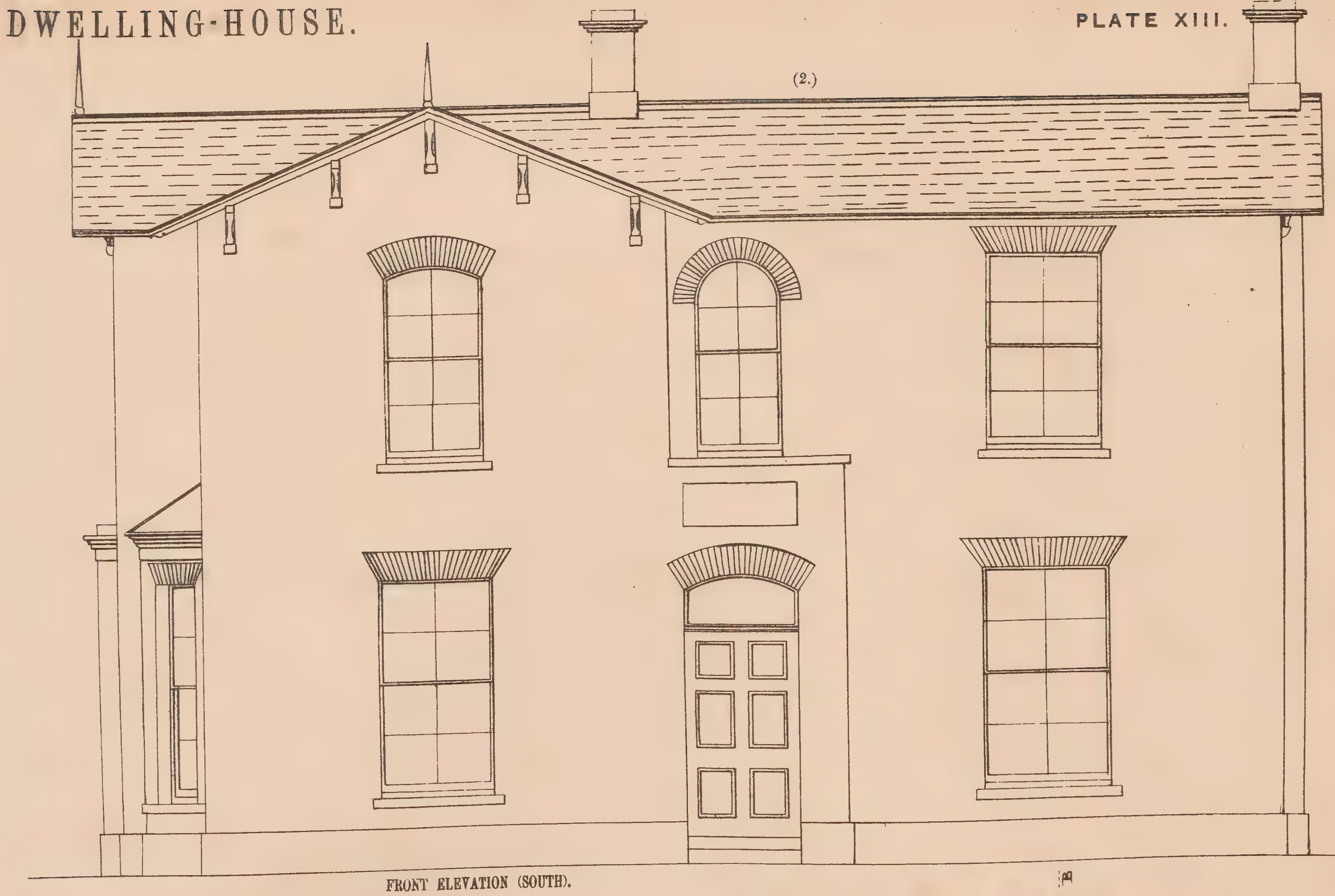
PLANS AND ELEVATIONS OF A DWELLING-HOUSE.

(1.)



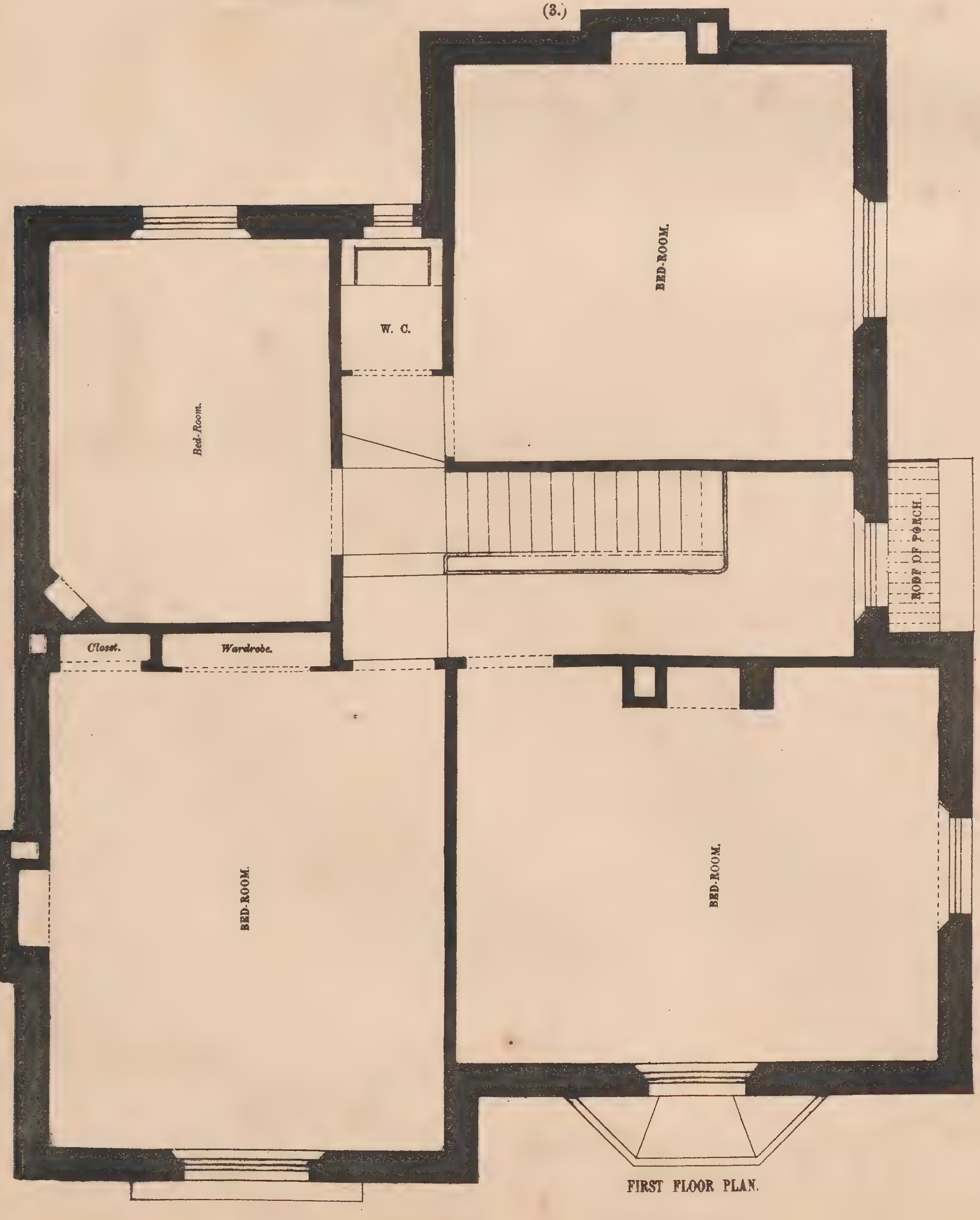
SIDE ELEVATION (WEST).

(2.)



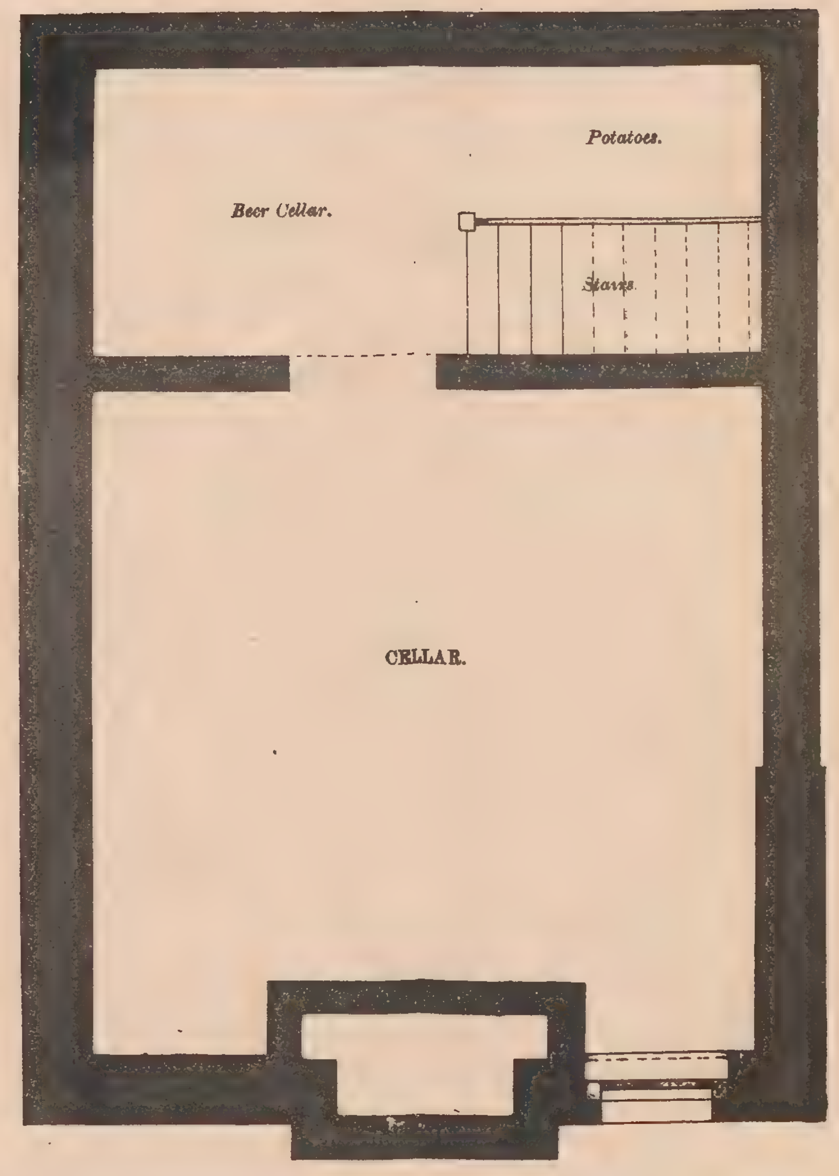
FRONT ELEVATION (SOUTH).

(3.)


Bed-Room.
W. C.
BED-ROOM.
ROOF OF PORCH.
Closet.
Wardrobe.
BED-ROOM.
BED-ROOM.

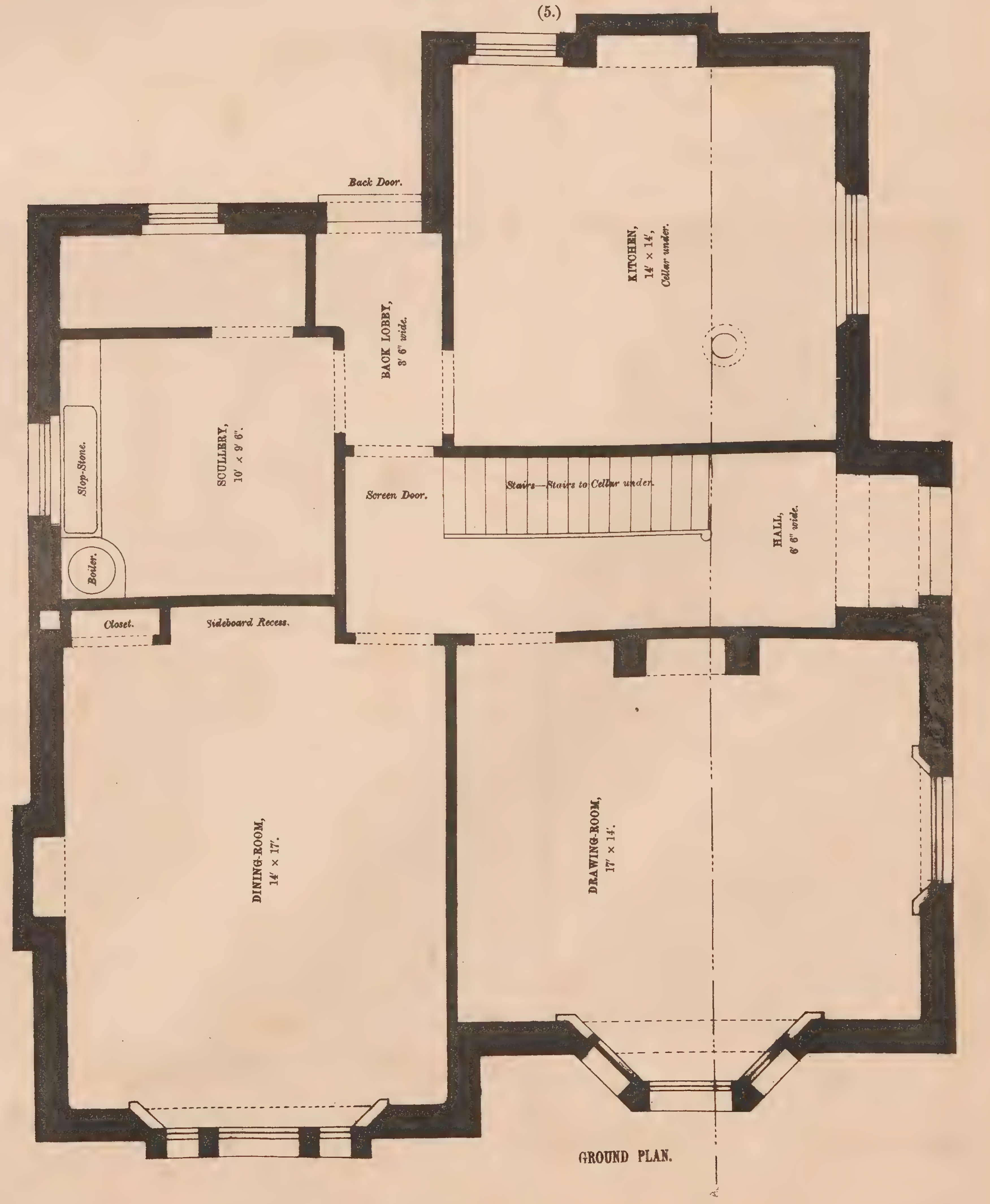
FIRST FLOOR PLAN.

(4.)


Potatoes.
Beer Cellar.
Stairs.
CELLAR.

CELLAR PLAN.

(5.)

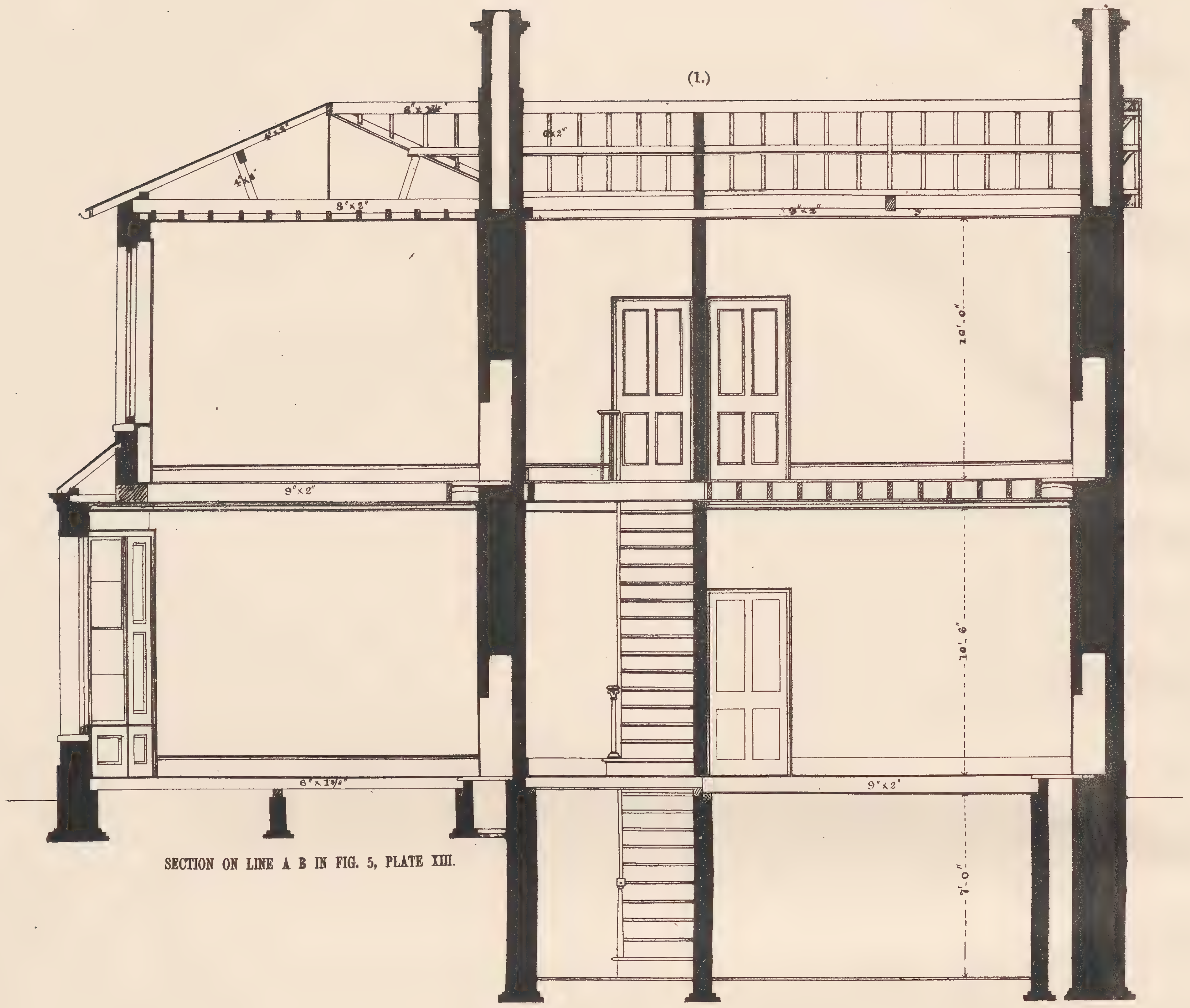

B
Back Door.
KITCHEN, 14' × 14', Cellar under.
BACK LOBBY, 3' 6" wide.
SCULLERY, 10' × 9' 6".
Slop-Stone.
Boiler.
Screen Door.
Stairs—Stairs to Cellar under.
HALL, 6' 6" wide.
Closet.
Sideboard Recess.
DINING-ROOM, 14' × 17'.
DRAWING-ROOM, 17' × 14'.

GROUND PLAN.

A. FULLARTON & CO., EDINBURGH AND LONDON.

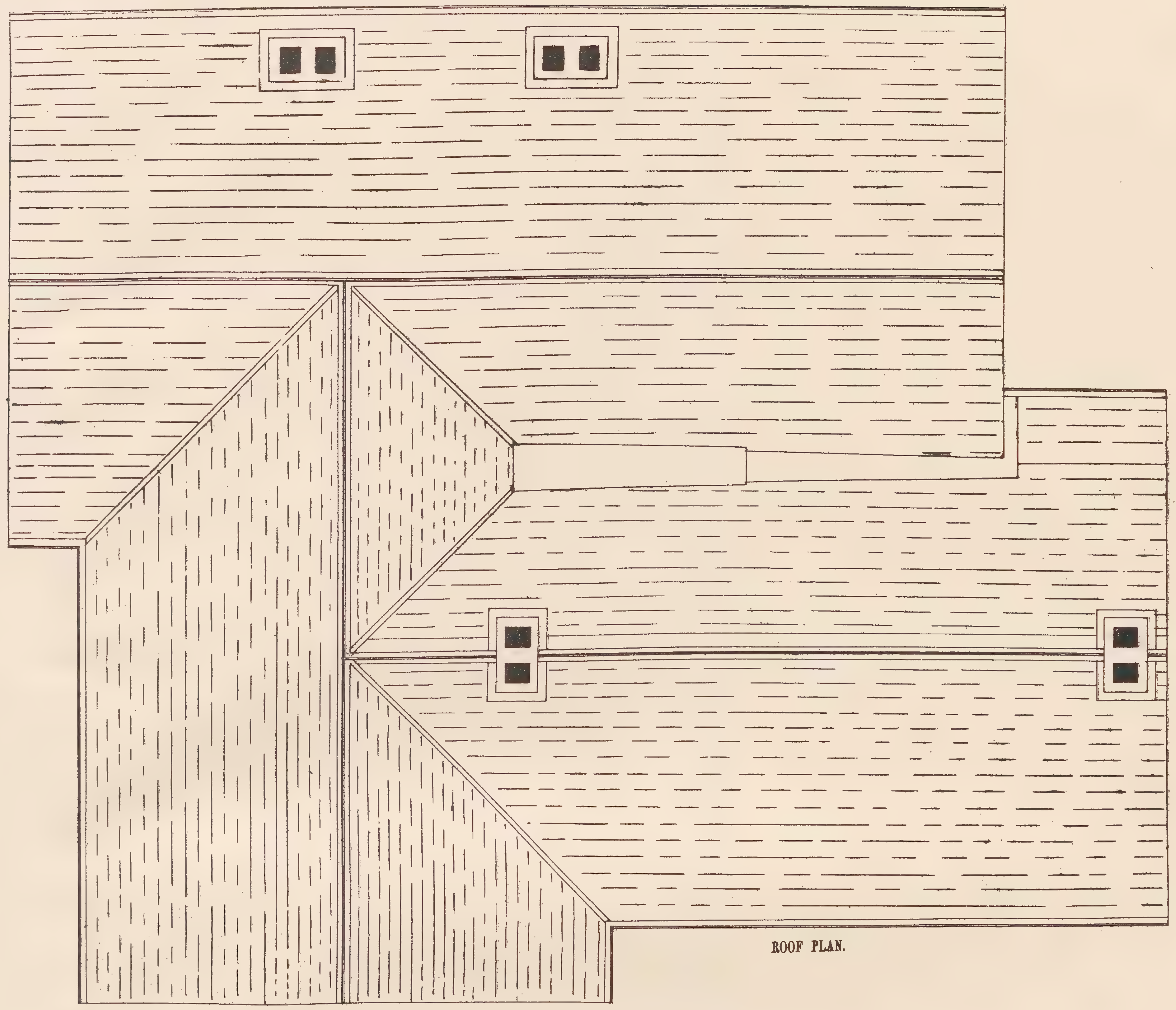
ELEVATION, SECTION, AND ROOF-PLAN OF DWELLING-HOUSE.

(1.)


8"×2"
9"×3"
10'.0"
9"×2"
10'.6"
6"×1¾"
9"×2"
7'.0"

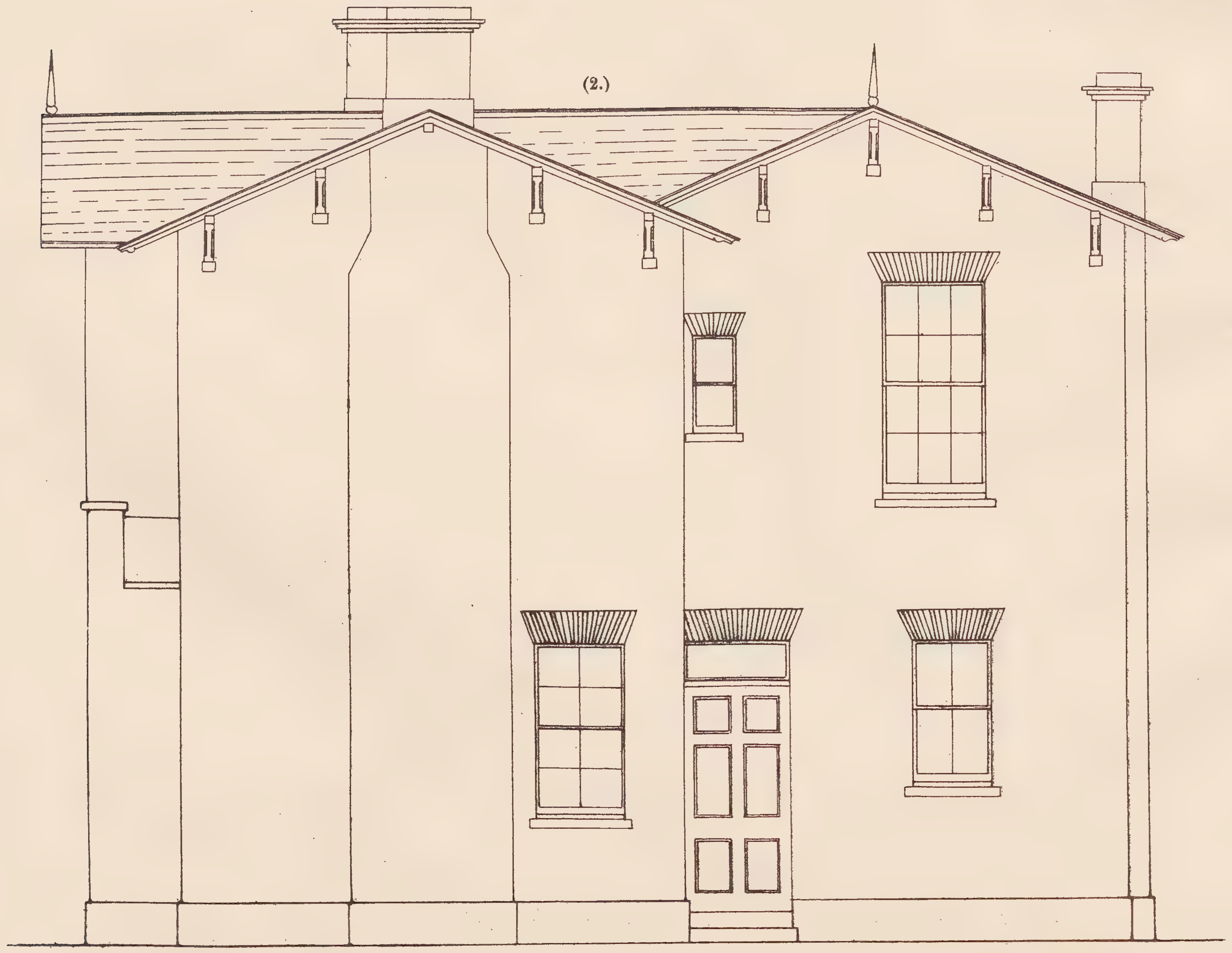
SECTION ON LINE A B IN FIG. 5, PLATE XIII.

(3.)



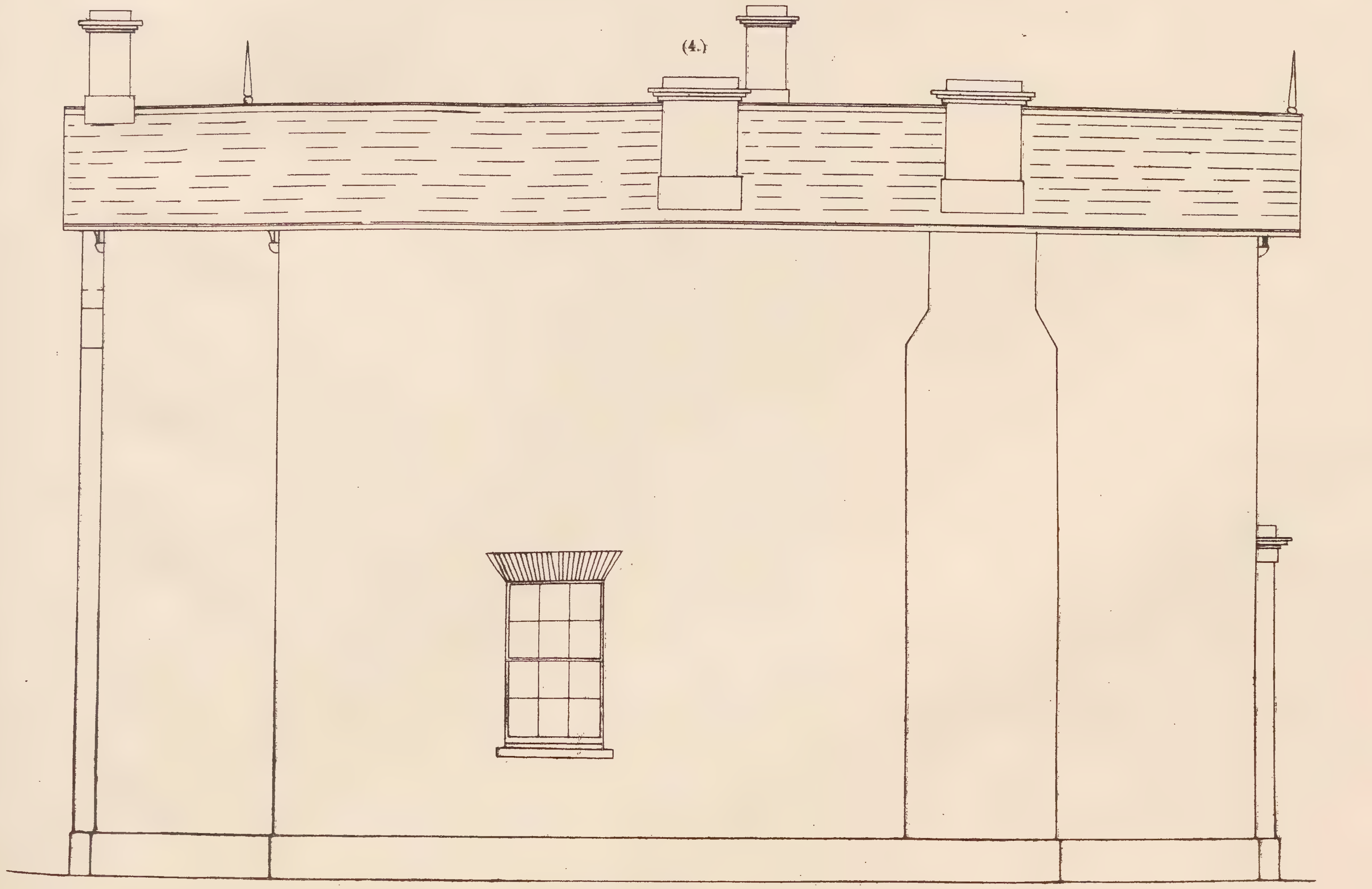
ROOF PLAN.

(2.)



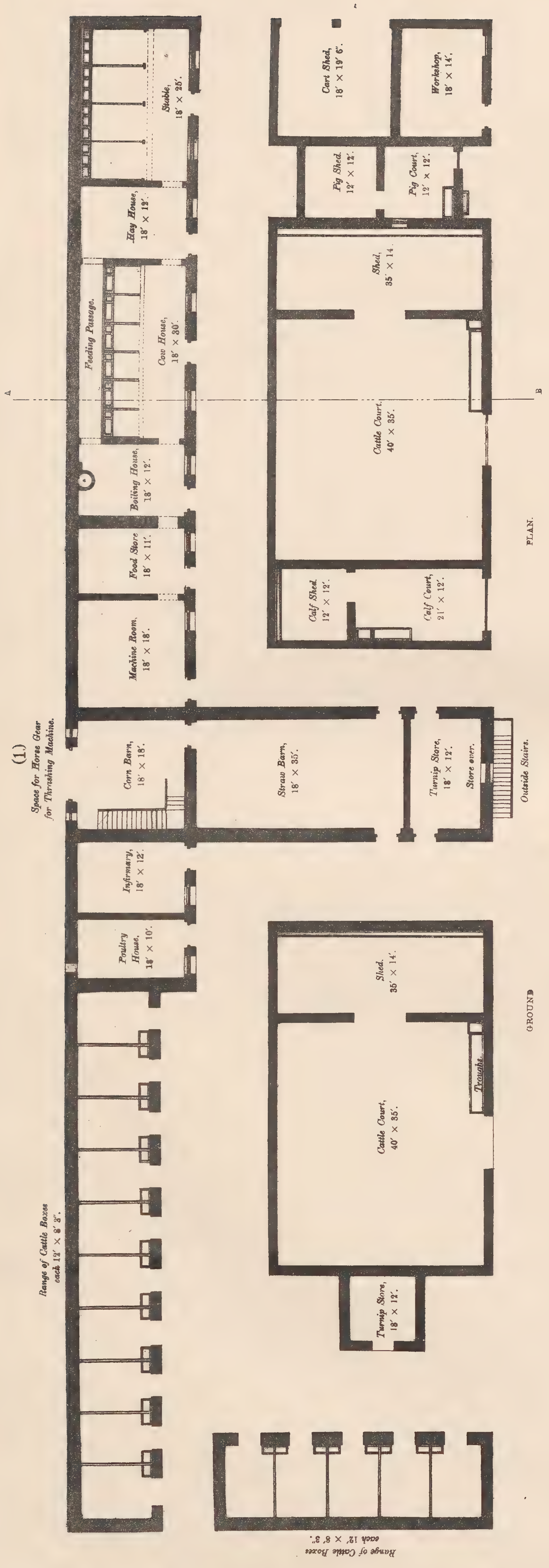
SIDE ELEVATION (EAST).

(4.)



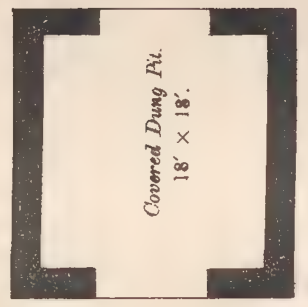
BACK ELEVATION.

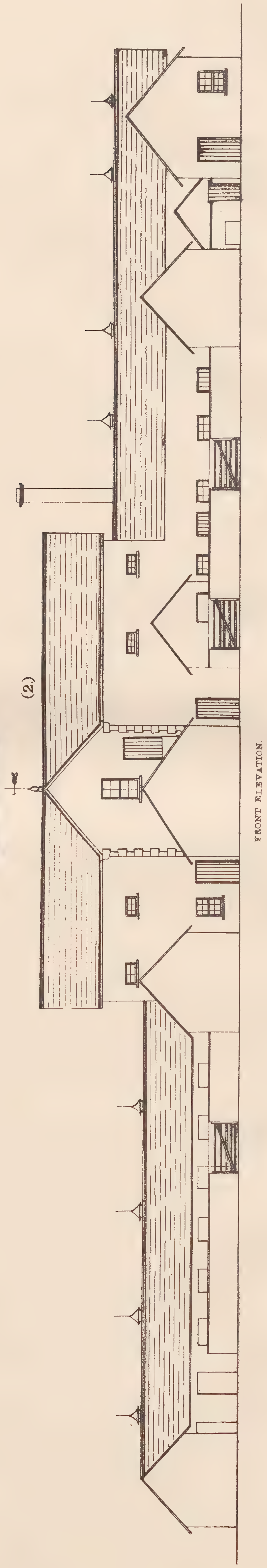
MIXED HUSBANDRY FARM STEADING FOR 100 OR 150 ACRES.


(1.)

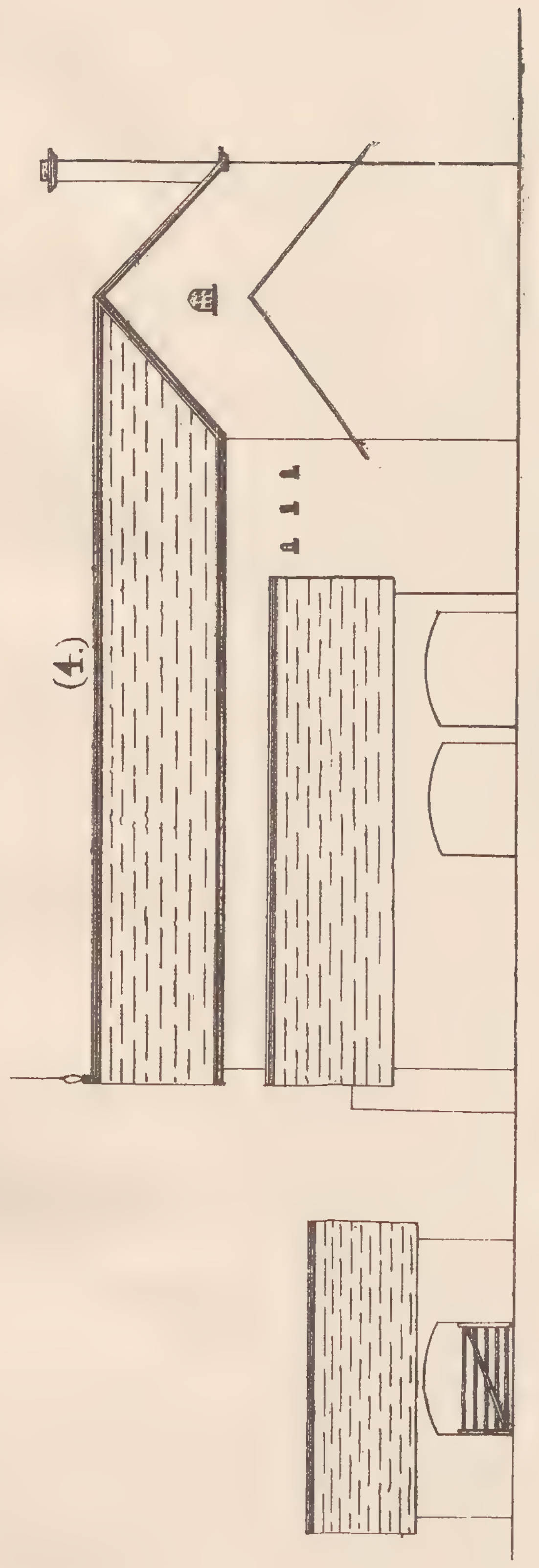
GROUND PLAN.

Space for Horse Gear for Thrashing Machine.
Stable, 18' × 25'.
Hay House, 18' × 12'.
Feeding Passage.
Cow House, 18' × 30'.
Boiling House, 18' × 12'.
Food Store 18' × 11'.
Machine Room. 18' × 18'.
Cart Shed, 18' × 19' 6".
Workshop, 18' × 14'.
Pig Shed. 12' × 12'.
Pig Court, 12' × 12'.
Shed, 35' × 14'.
Cattle Court. 40' × 35'.
Calf Shed. 12' × 12'.
Calf Court, 21' × 12'.
A
B
Corn Barn, 18' × 18'.
Straw Barn, 18' × 35'.
Turnip Store, 18' × 12'.
Store over.
Outside Stairs.
Infirmary, 18' × 12'.
Poultry House. 18' × 10'.
Shed. 35' × 14'.
Troughs.
Cattle Court, 40' × 35'.
Turnip Store, 18' × 12'.
Range of Cattle Boxes each 12' × 8' 3".
Range of Cattle Boxes each 12' × 8' 3".

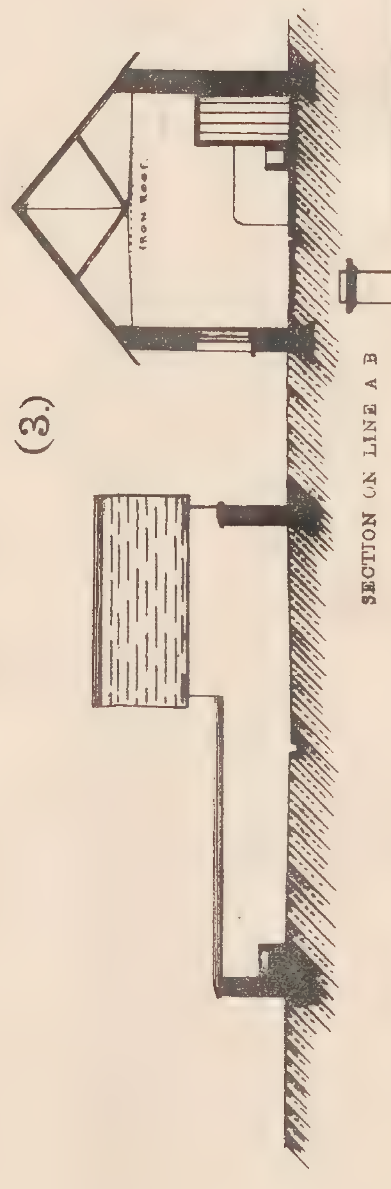

Covered Dung Pit. 18' × 18'.


(2)

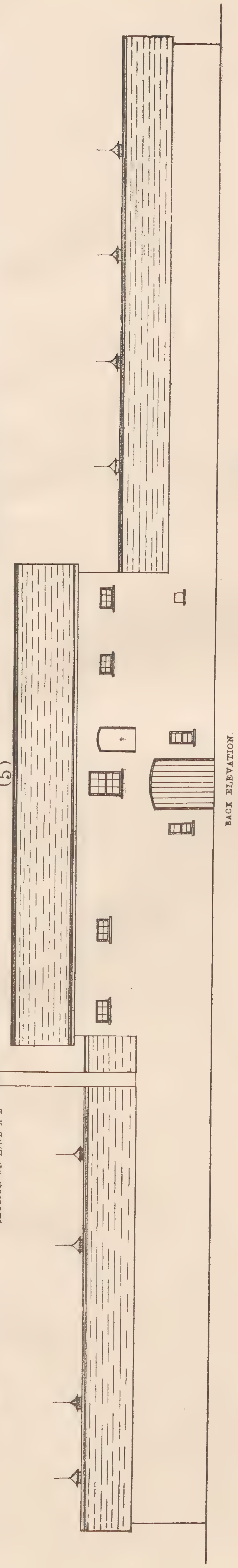
FRONT ELEVATION.


(4.)

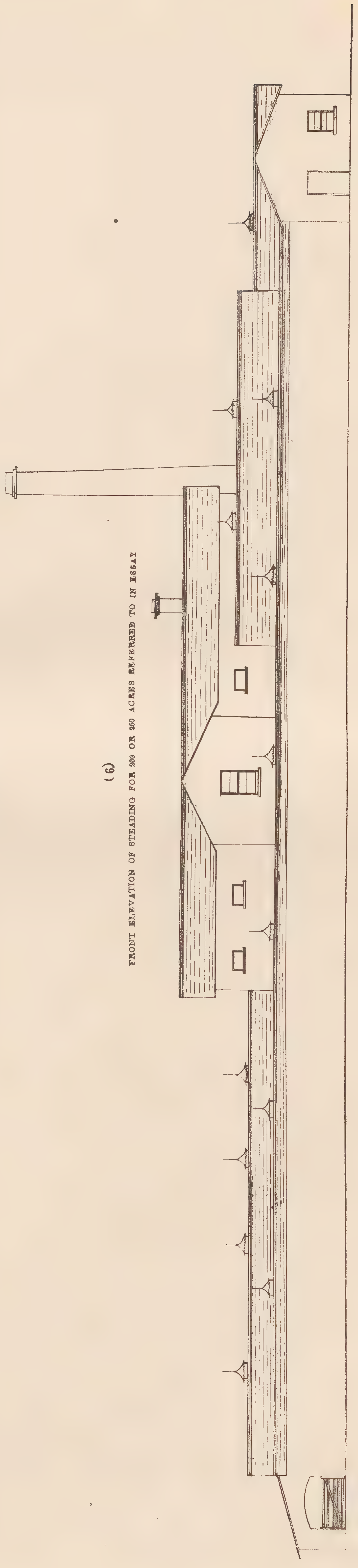
END ELEVATION AT C.


(3)

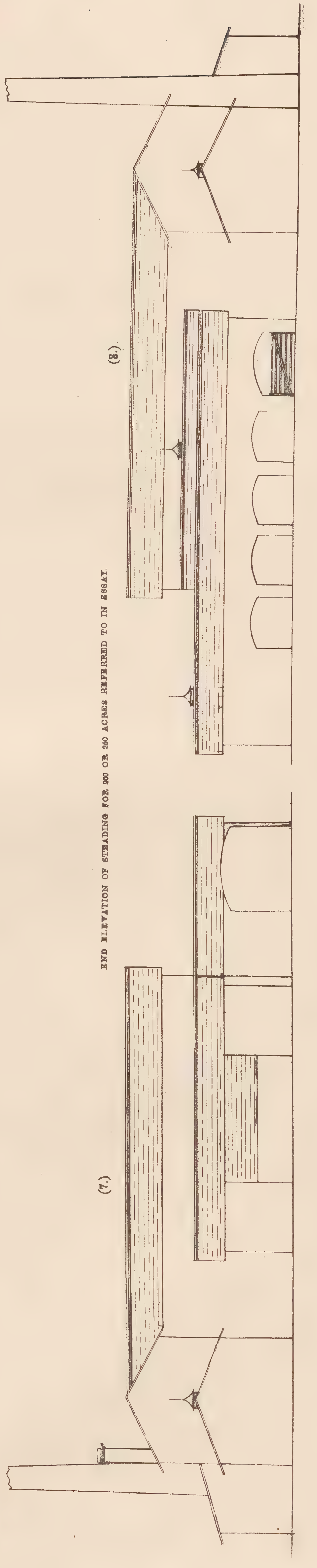
SECTION ON LINE A B


(5)

BACK ELEVATION

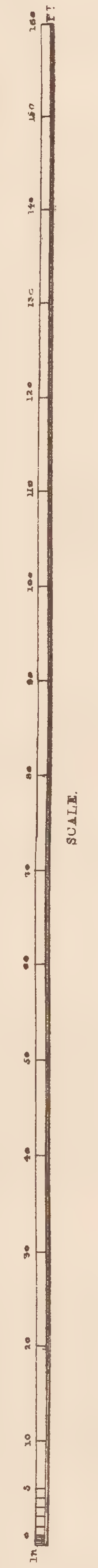

(6)

FRONT ELEVATION OF STEADING FOR 200 OR 250 ACRES REFERRED TO IN ESSAY


(8.)

(7.)

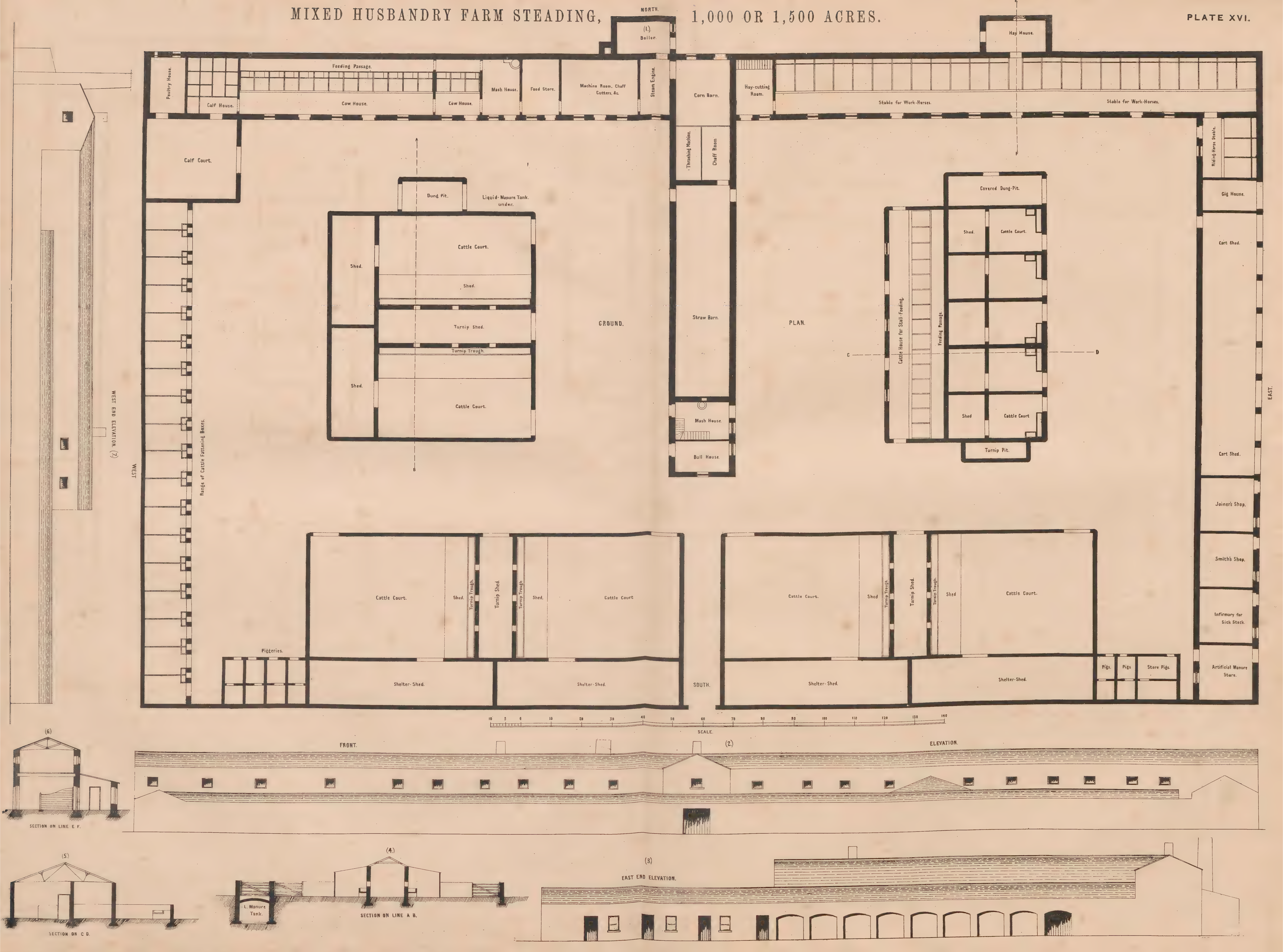
END ELEVATION OF STEADING FOR 200 OR 250 ACRES REFERRED TO IN ESSAY


SCALE.

In
0
5
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
FT

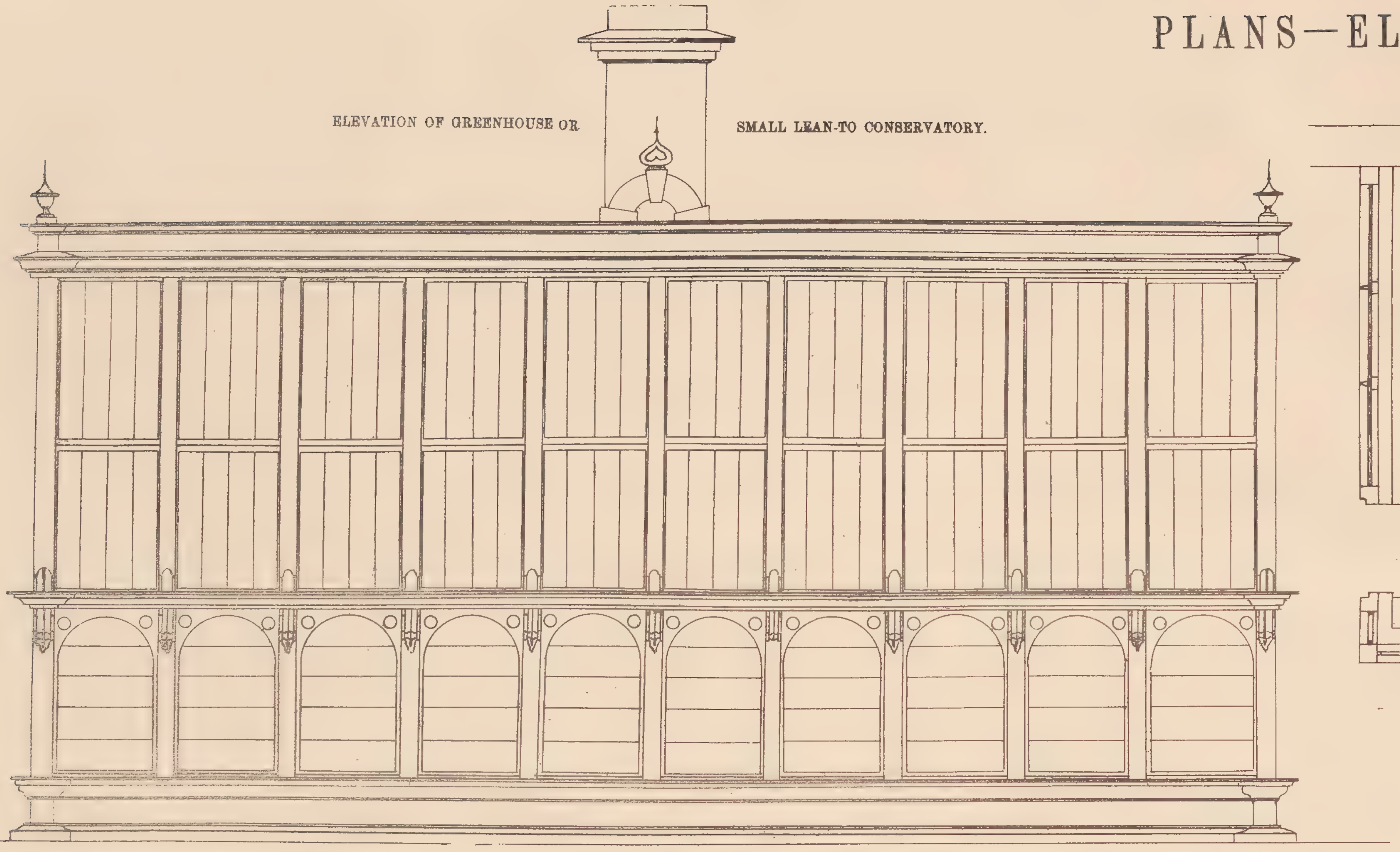
MIXED HUSBANDRY FARM STEADING, 1,000 OR 1,500 ACRES.

PLATE XVI.


NORTH.
(1.)
Boiler.
Hay House.
Poultry House.
Calf House.
Feeding Passage.
Cow House.
Cow House.
Mash House.
Food Store.
Machine Room, Chaff Cutters, &c.
Steam Engine.
Corn Barn.
Hay-cutting Room.
Stable for Work-Horses.
Stable for Work-Horses.
Calf Court.
Thrashing Machine.
Chaff Room
Riding-Horse Stable.
Gig House.
Dung Pit.
Liquid-Manure Tank. under.
Covered Dung-Pit.
Shed.
Cattle Court.
Shed.
Turnip Shed.
Turnip Trough.
Shed.
Cattle Court.
GROUND.
Straw Barn.
PLAN.
Shed.
Cattle Court.
Cattle House for Stall-Feeding.
Feeding Passage.
C
D
Shed
Cattle Court
Turnip Pit.
Cart Shed.
Cart Shed.
Mash House.
Bull House.
E
F
B
WEST
EAST.
WEST END ELEVATION. (7.)
Range of Cattle Fattening Boxes.
Joiner's Shop.
Smith's Shop.
Infirmary for Sick Stock.
Artificial Manure Store.
Cattle Court.
Shed.
Turnip Trough
Turnip Shed
Turnip Trough
Shed.
Cattle Court
Cattle Court.
Shed
Turnip Trough
Turnip Shed
Turnip Trough
Shed
Cattle Court.
Piggeries.
Shelter-Shed.
Shelter-Shed.
SOUTH.
Shelter-Shed.
Shelter-Shed.
Pigs.
Pigs
Store Pigs.
10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140
SCALE.
(6.)
SECTION ON LINE E F.
FRONT.
(2.)
ELEVATION.
(5.)
SECTION ON C D.
L. Manure Tank.
(4.)
SECTION ON LINE A B.
(3.)
EAST END ELEVATION.

PLANS—ELEVATIONS AND DETAILS OF GREENHOUSES, &c.

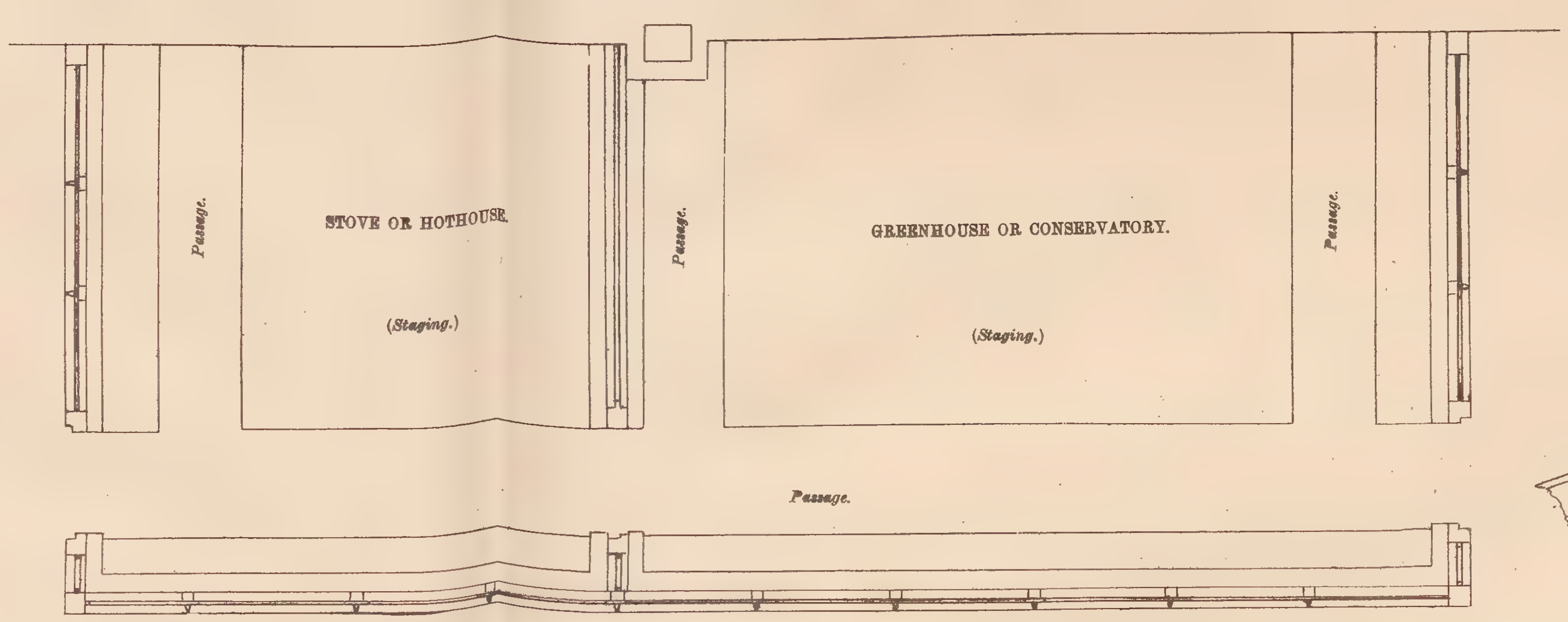
(1.)



ELEVATION OF GREENHOUSE OR SMALL LEAN-TO CONSERVATORY.

(2.)

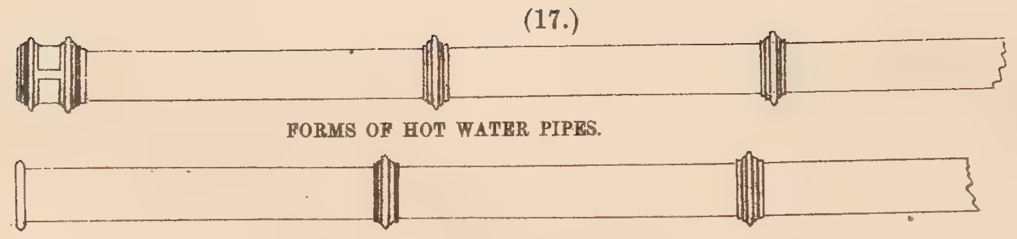
PLAN OF GREENHOUSE IN FIG. 1.


Passage.
STOVE OR HOTHOUSE.
(Staging.)
Passage.
GREENHOUSE OR CONSERVATORY.
(Staging.)
Passage.
Passage.

SCALE FOR FIGS. 1 AND 2.

10
0
2
4
6
8
10
15
20
25
30

(17.)

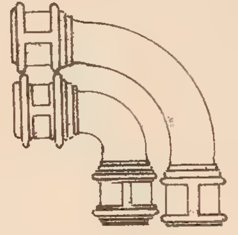


FORMS OF HOT WATER PIPES.

(16.)

MOISTURE TROUGH.

(15.)

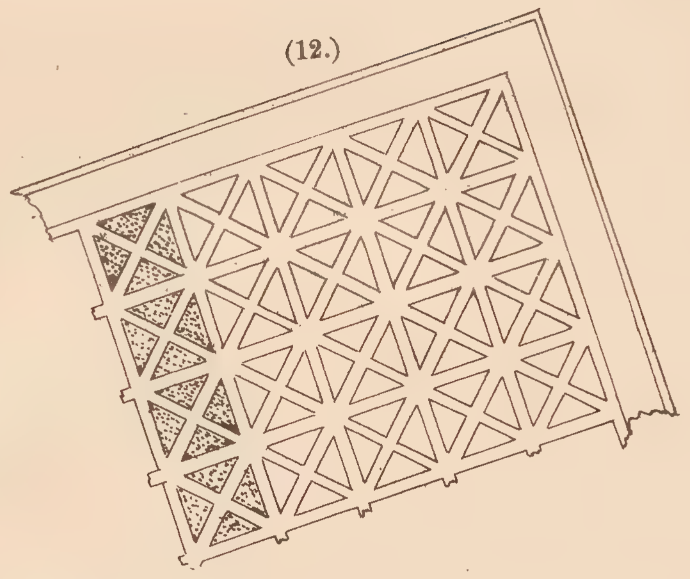


Elbows.

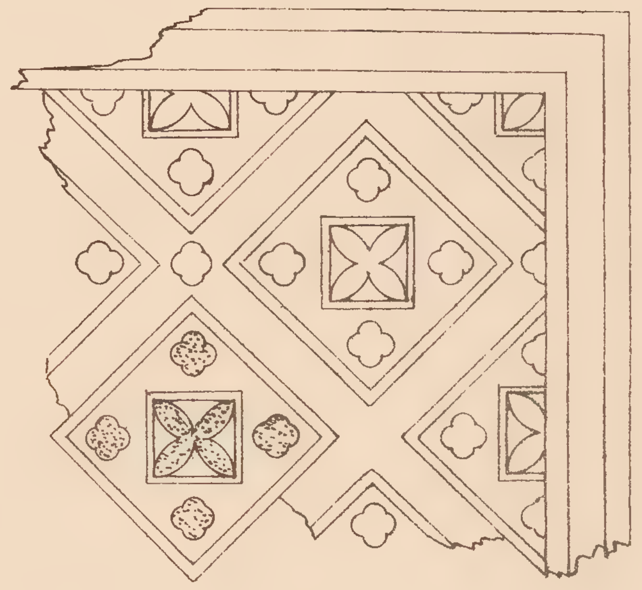
(14.)

CHAIRS FOR PIPES.

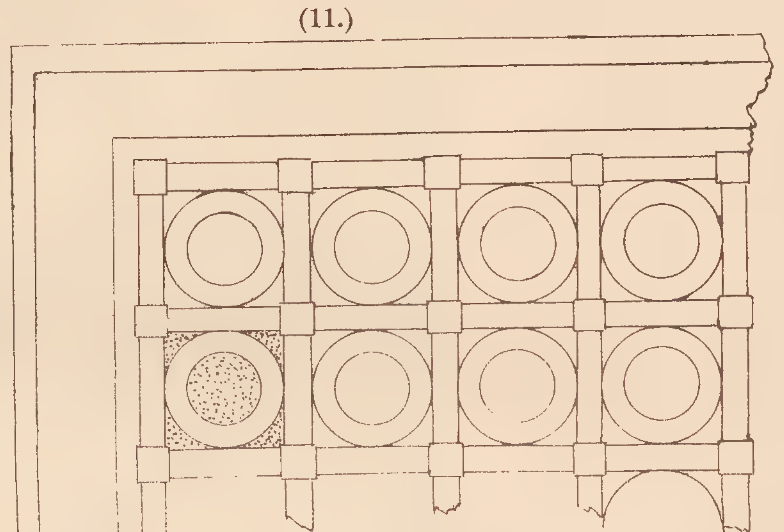
(12.)



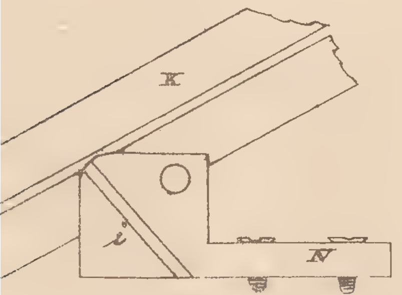
(13.)



(11.)

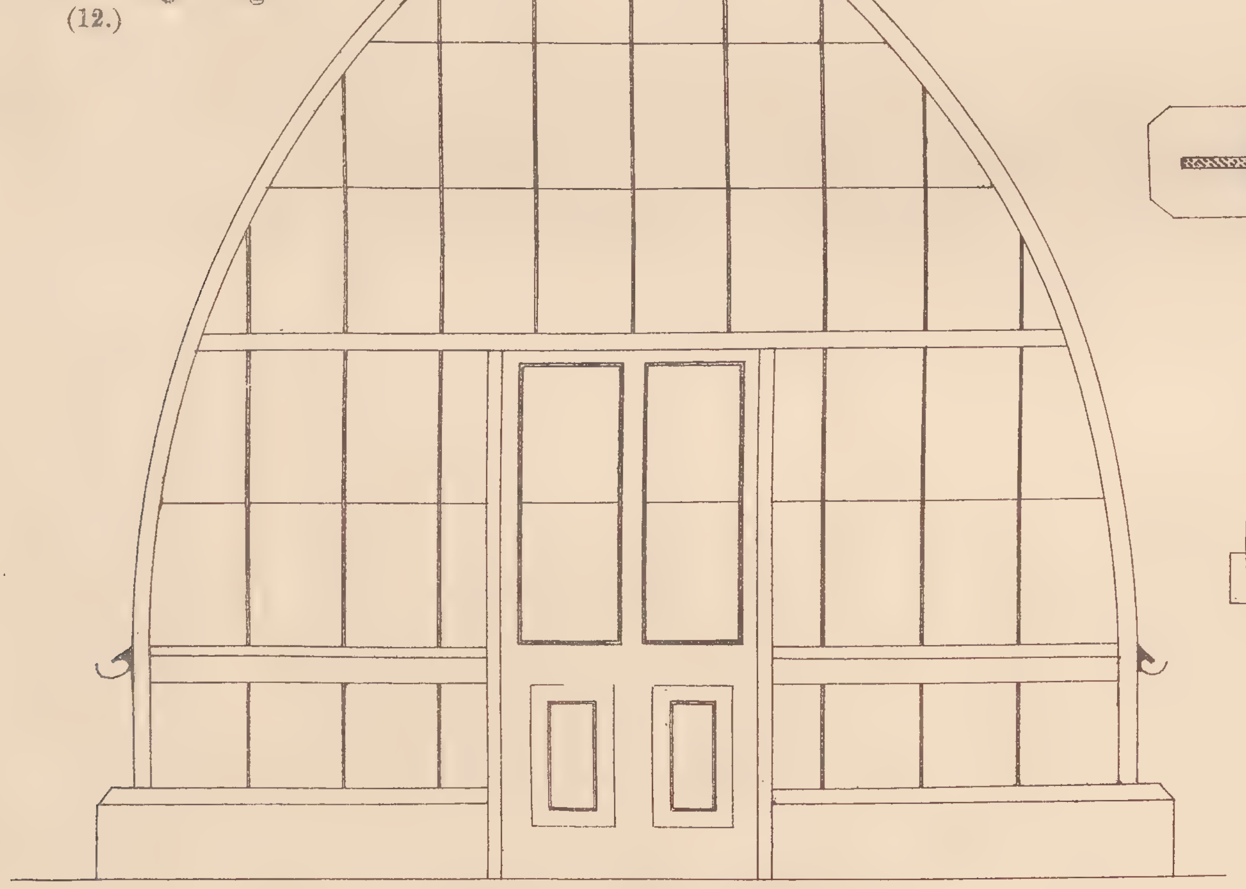


GRATINGS.



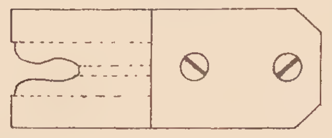
(12.)

(5.)

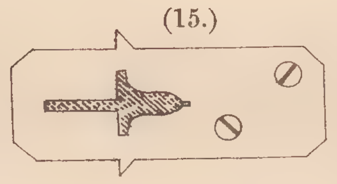


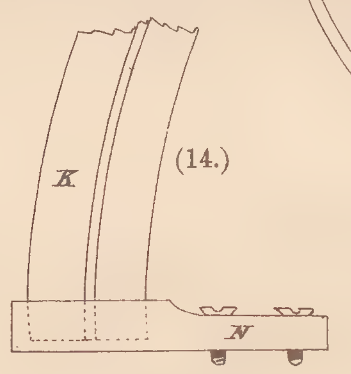
END ELEVATION OF SPAN-ROOF GREENHOUSE.
SCALE ½ INCH = 1 FOOT.

(13.)



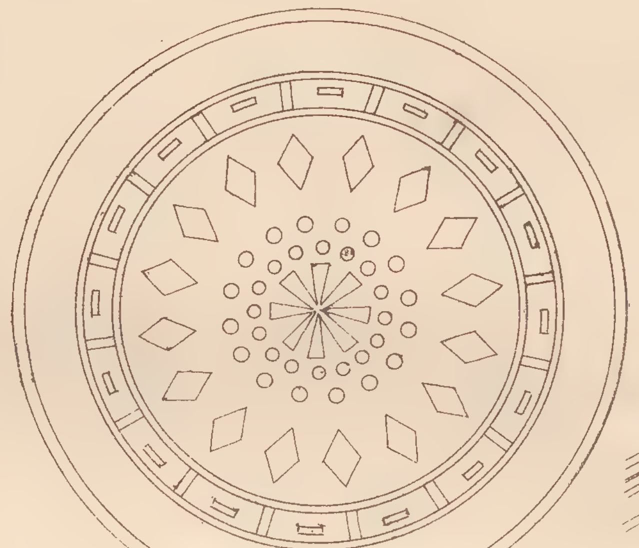
(15.)



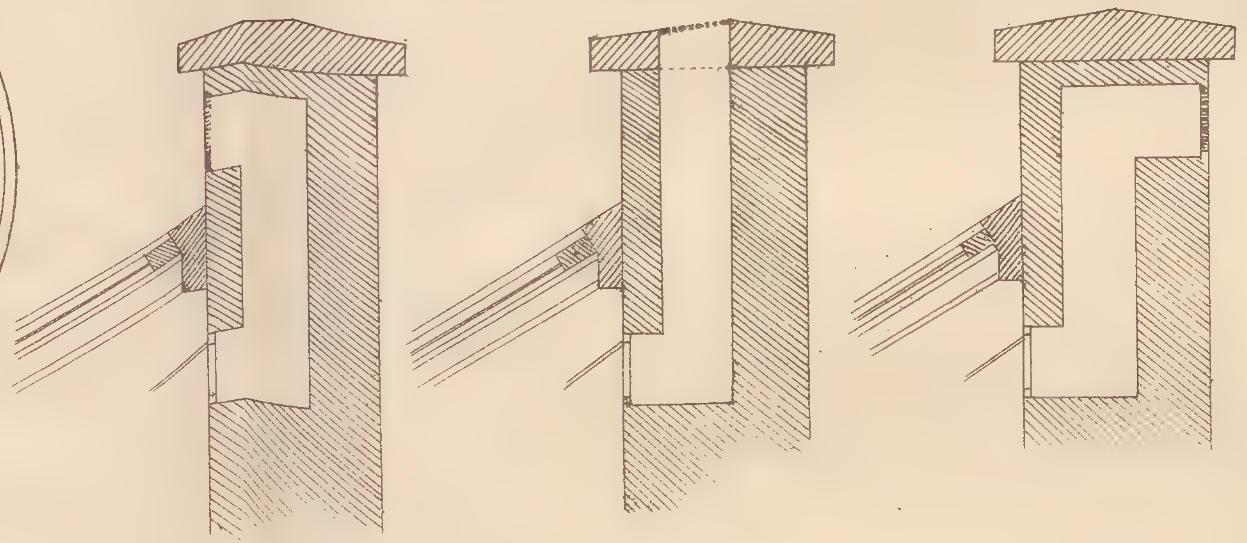


(14.)

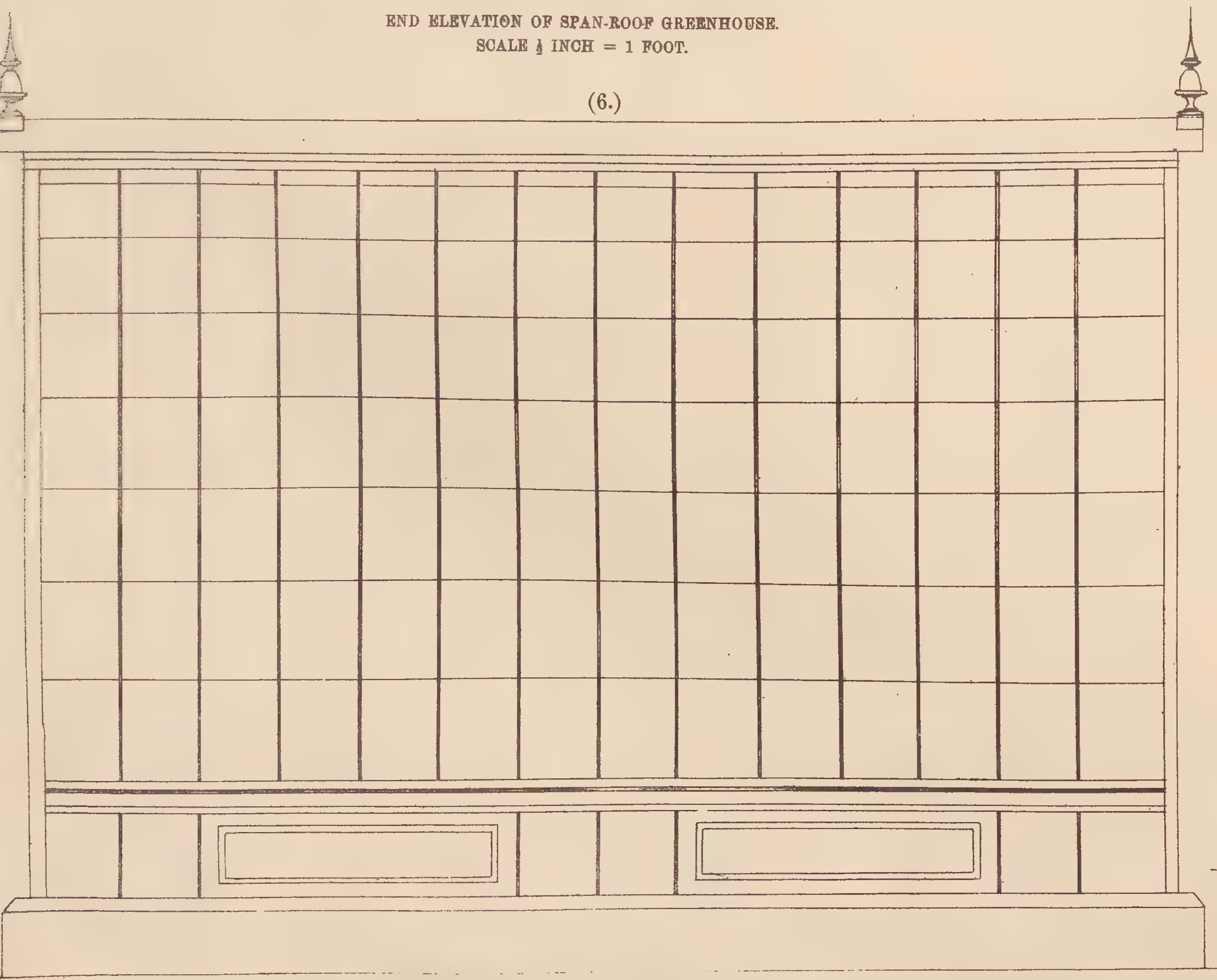
GRATING FOR PASSAGE.



METHODS OF VENTILATING GREENHOUSES AT BACK WALLS.
SCALE 2 INCHES = 1 FOOT.

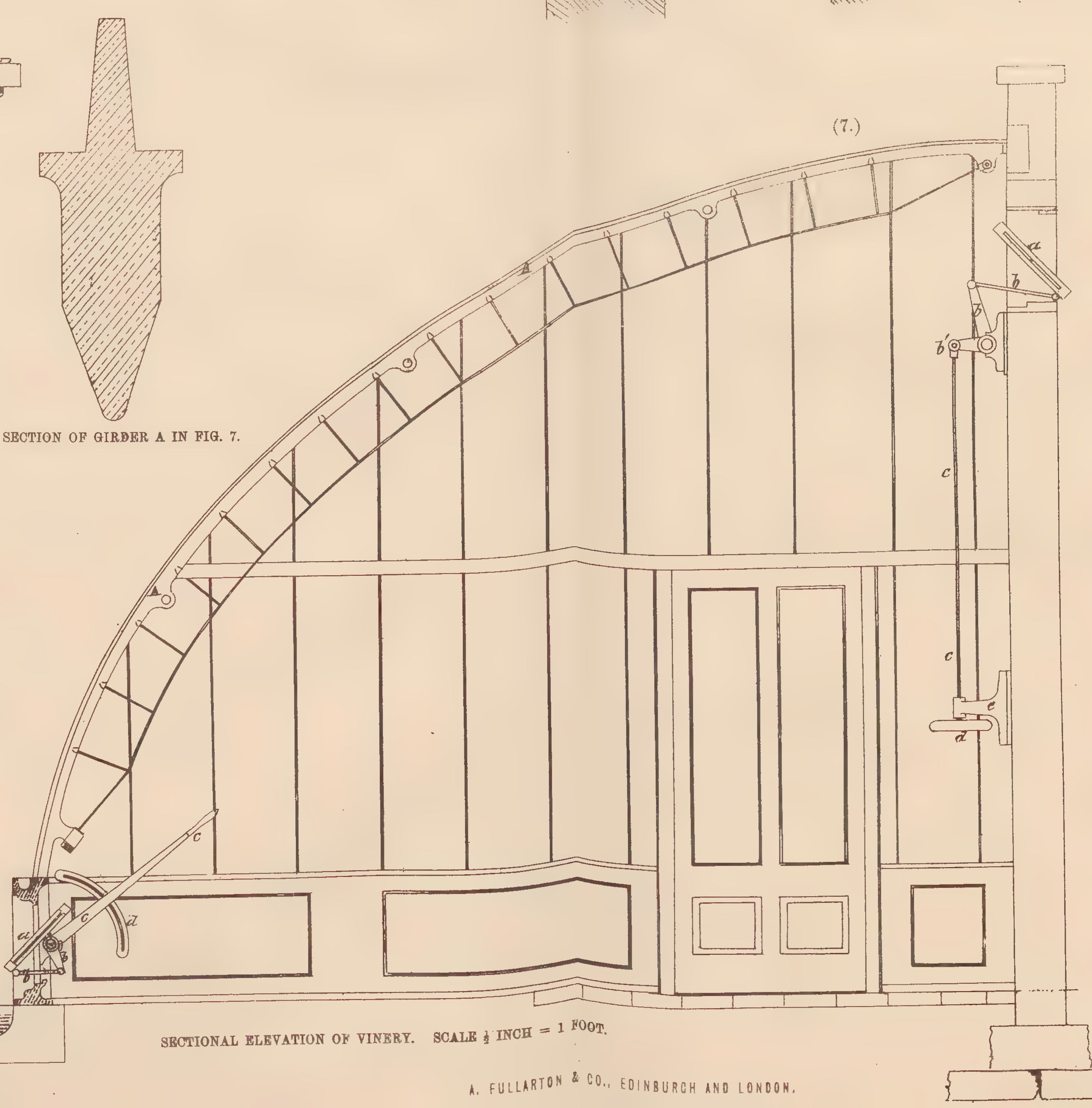


(6.)



SIDE ELEVATION OF GREENHOUSE IN FIG. 5.

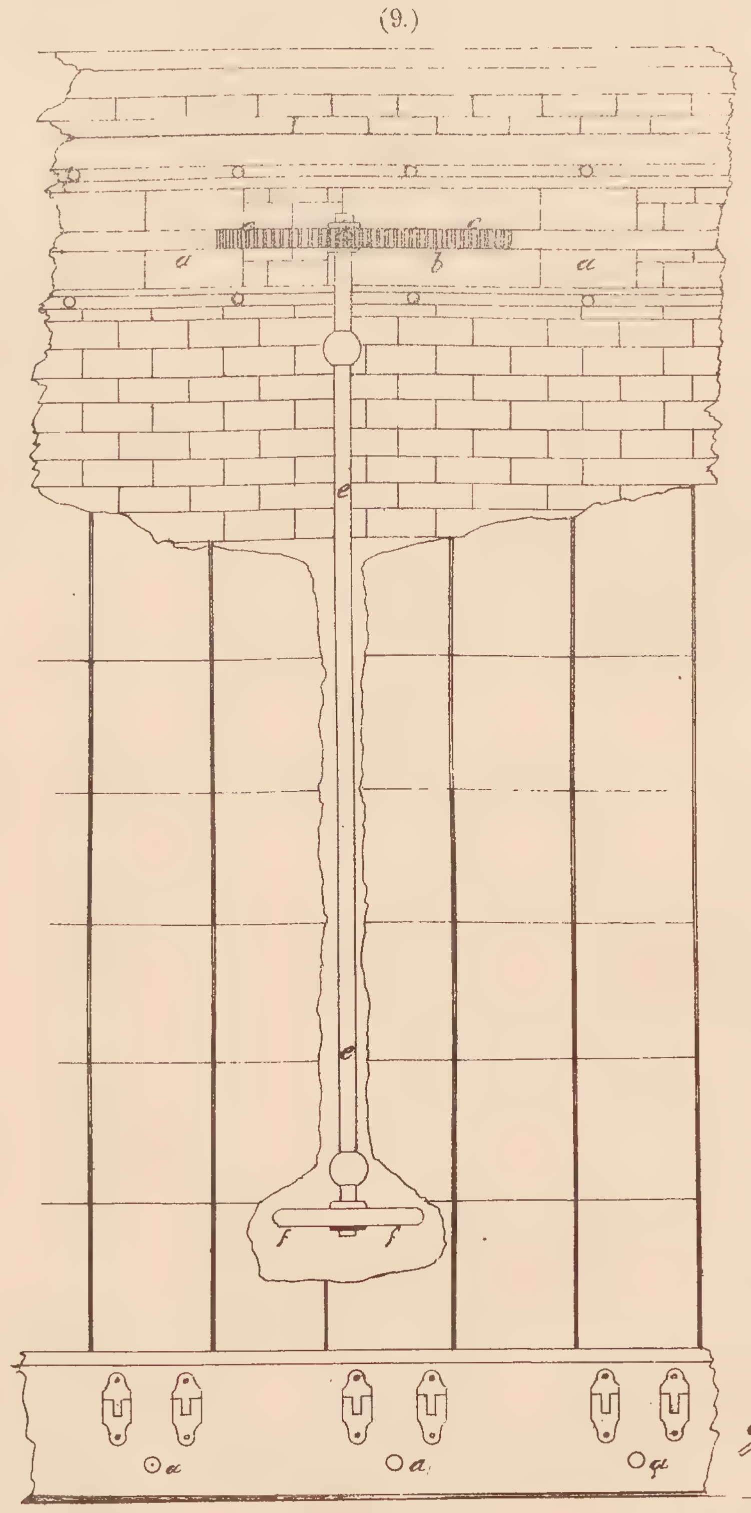
(7.)


A
a
b
b'
c
c
d
A
c
a
c
d
b
b

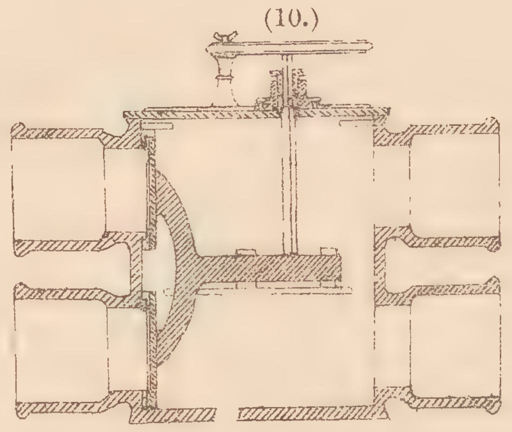
SECTION OF GIRDER A IN FIG. 7.

SECTIONAL ELEVATION OF VINERY. SCALE ½ INCH = 1 FOOT.

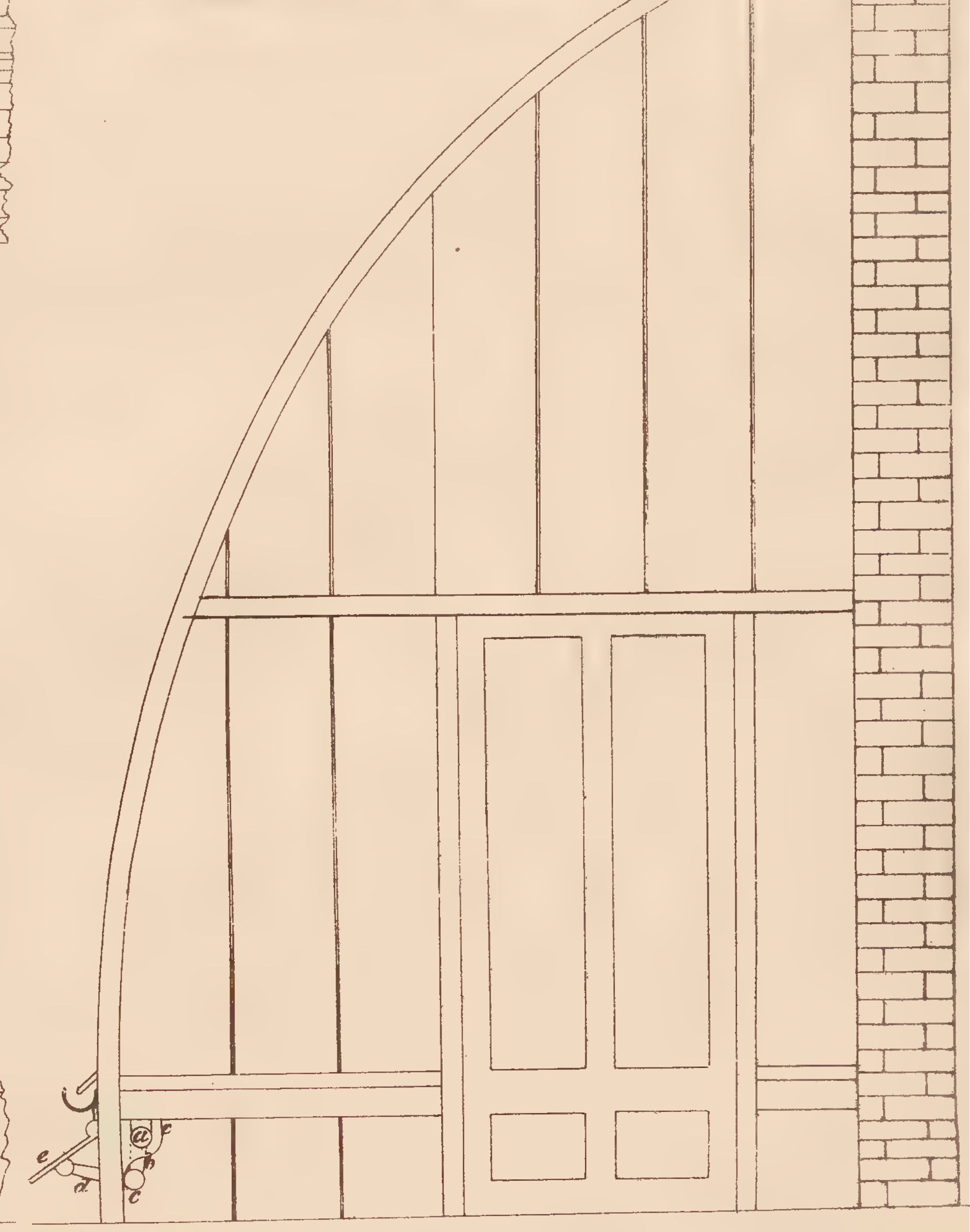
(9.)


a
c
b
a
e
e
f
f
a
a
a

(10.)



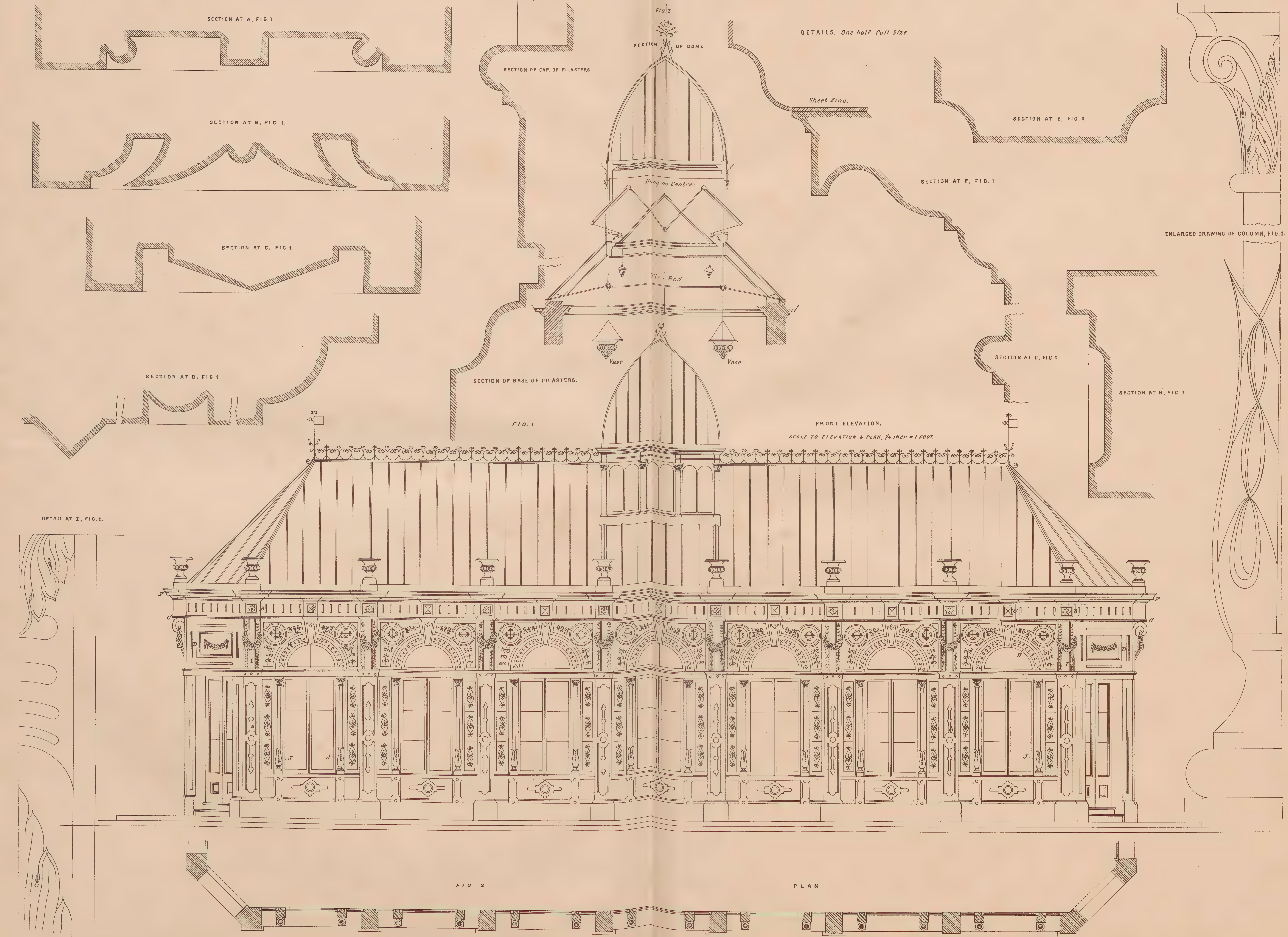
(8.)



END SECTION OF PEACH HOUSE. SCALE ½ INCH = 1 FOOT.

A. FULLARTON & CO., EDINBURGH AND LONDON.

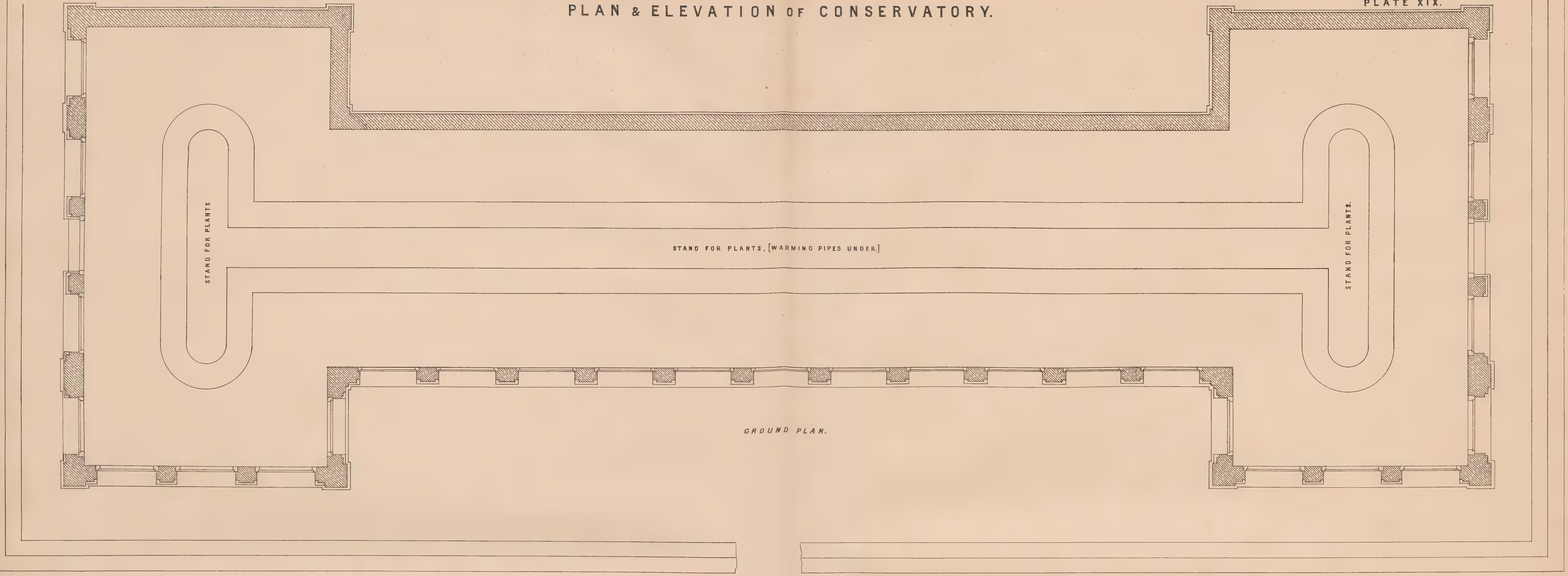
DESIGN FOR CONSERVATORY—PLAN, ELEVATION, & DETAILS.

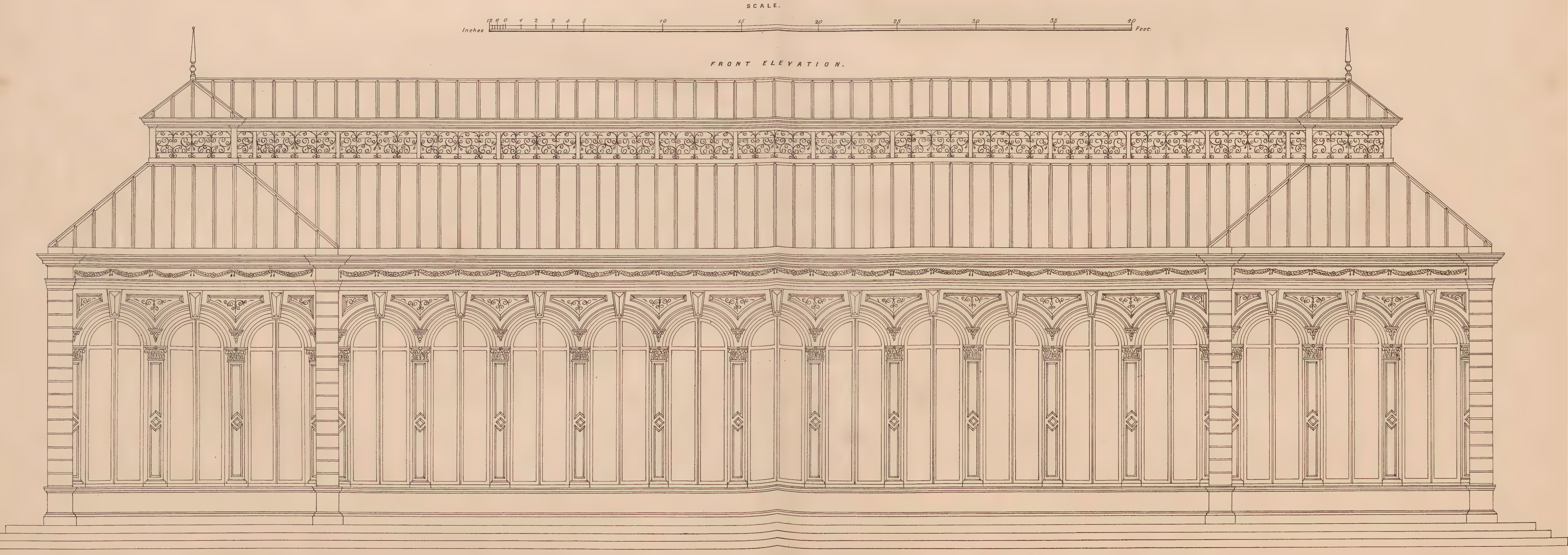

SECTION AT A, FIG. 1.
SECTION AT B, FIG. 1.
SECTION AT C, FIG. 1.
SECTION AT D, FIG. 1.
SECTION OF CAP. OF PILASTERS
SECTION OF BASE OF PILASTERS.
FIG. 3
SECTION OF DOME
Hung on Centres.
Tie-Rod
Vase
Vase
DETAILS, One-half full Size.
Sheet Zinc.
SECTION AT E, FIG. 1.
SECTION AT F, FIG. 1
SECTION AT G, FIG. 1.
SECTION AT H, FIG. 1
ENLARGED DRAWING OF COLUMN, FIG. 1.
DETAIL AT I, FIG. 1.
FIG. 1
FRONT ELEVATION.
SCALE TO ELEVATION & PLAN, 1/4 INCH = 1 FOOT.
F
F
G
G
B
B
C
C
D
D
I
I
H
A
A
J
J
J
FIG. 2.
PLAN

J. W. BOGUE, LITH.

PLATE XIX.

PLAN & ELEVATION of CONSERVATORY.


STAND FOR PLANTS
STAND FOR PLANTS, [WARMING PIPES UNDER.]
STAND FOR PLANTS.
GROUND PLAN.


SCALE.
Inches
12
6
0
1
2
3
4
5
10
15
20
25
30
35
40
Feet.
FRONT ELEVATION.

J. W. BOGUE, LITH.

PLATE XX.

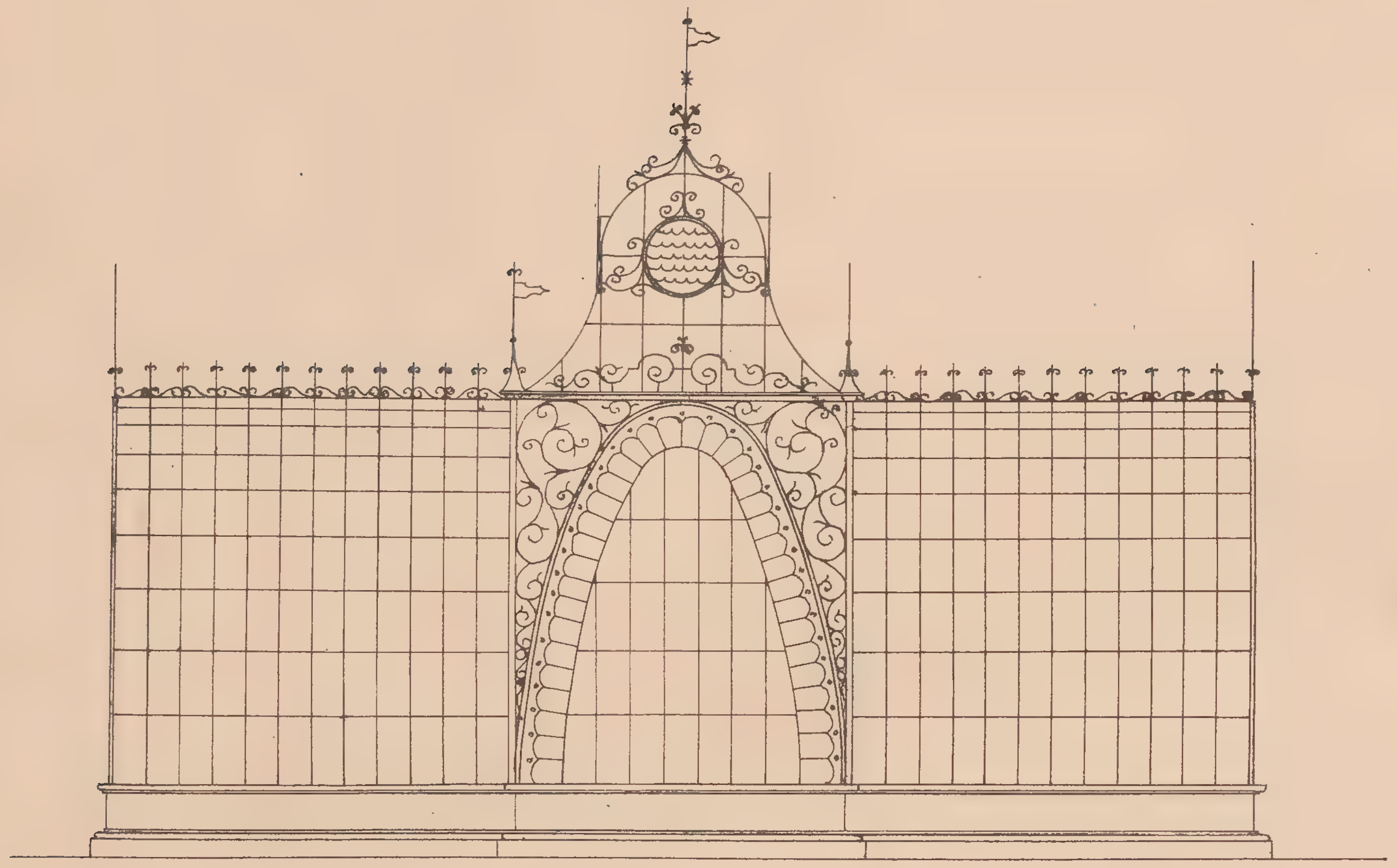
DESIGNS FOR IRON CONSERVATORIES.

FIGS. 1, 2, 3, 4, 5.

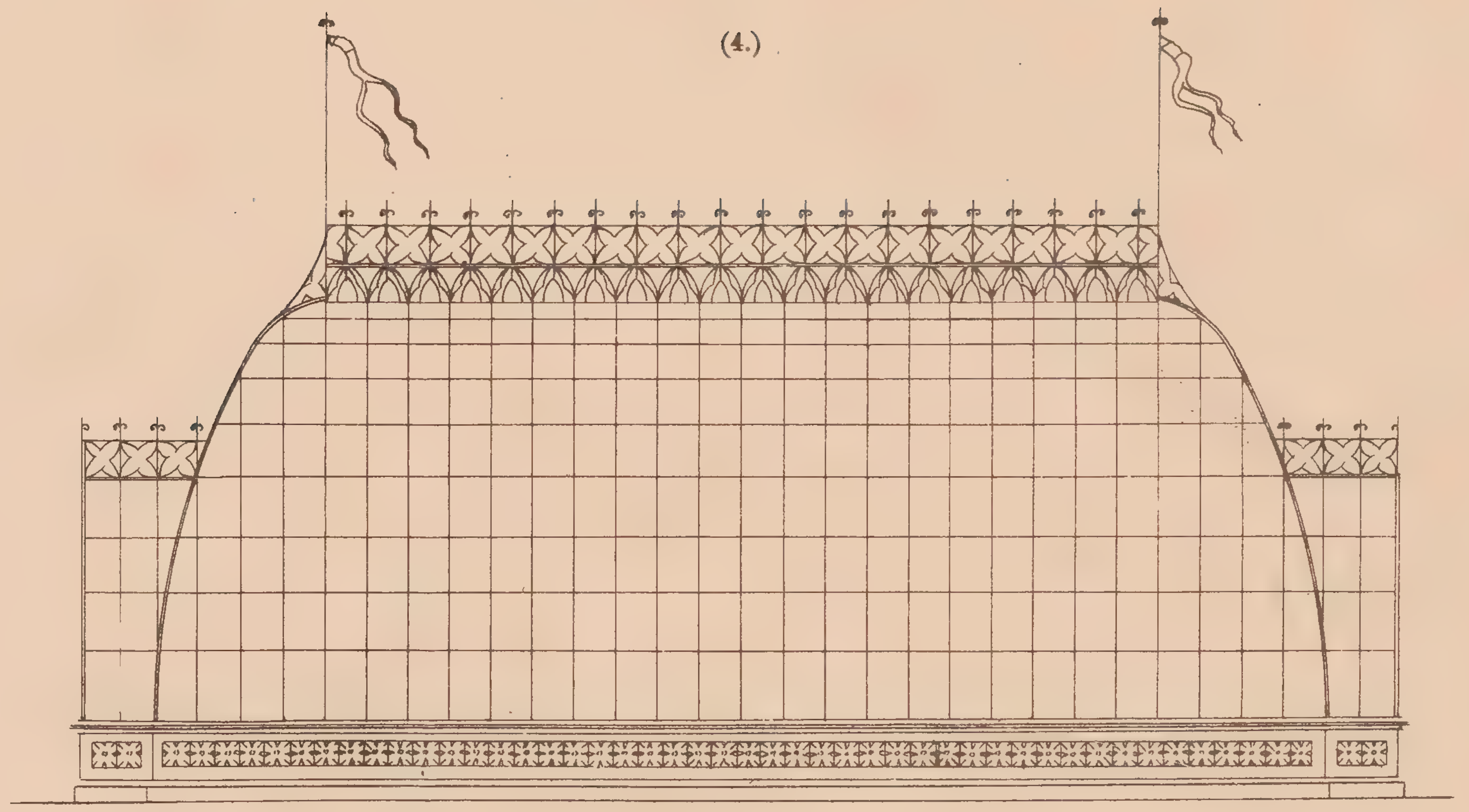
DESIGNS FOR SCHOOL ELEVATIONS.

FIGS. 6, 7, 8.

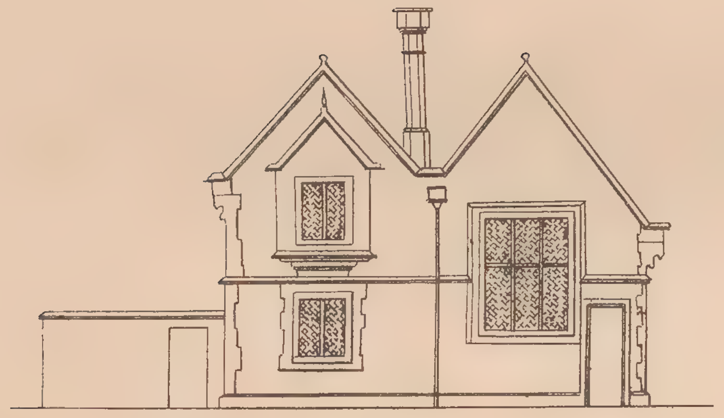
(2.)



(4.)

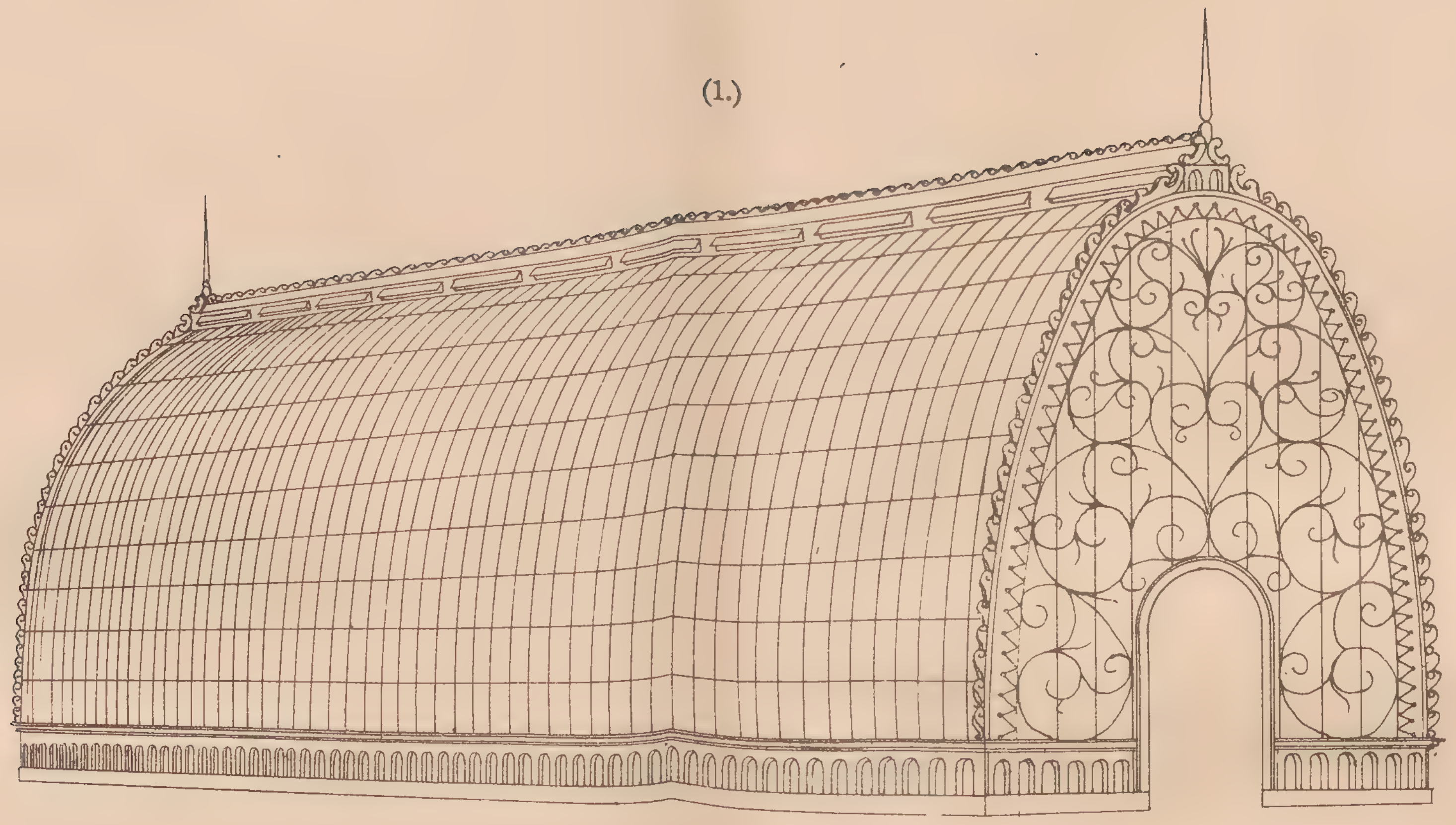


(6.)

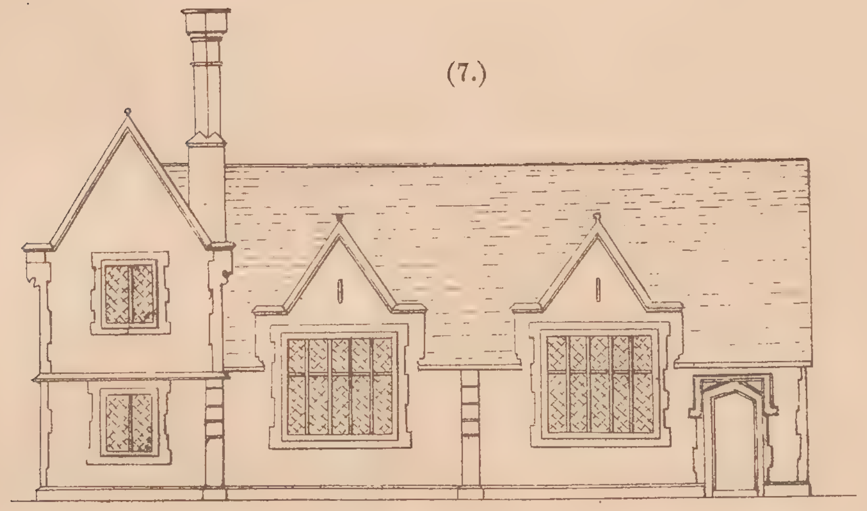


ELEVATION OF SCHOOL, PLAN IN Fig. 13.
ESSAY EIGHTH.

(1.)

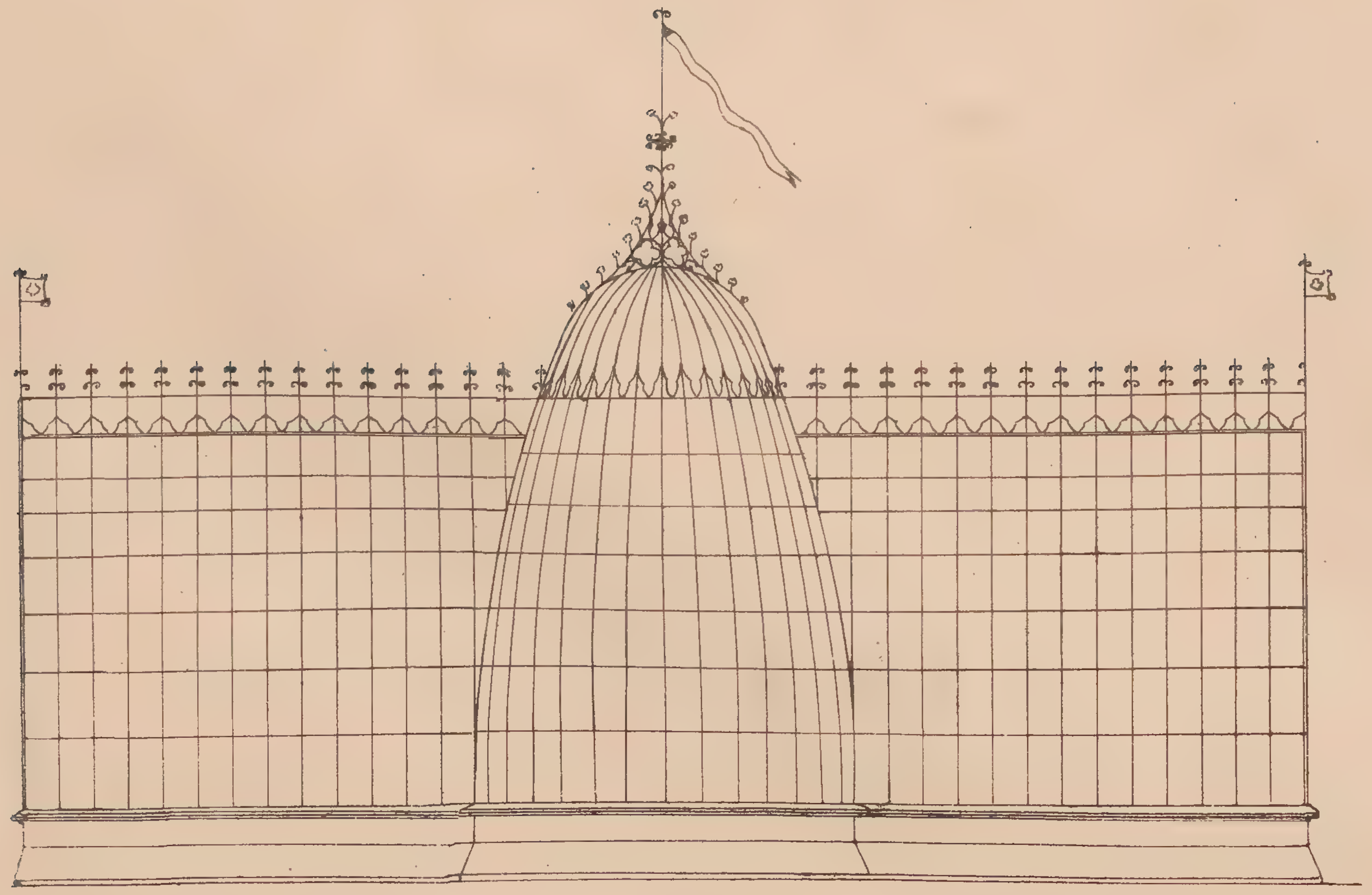


(7.)

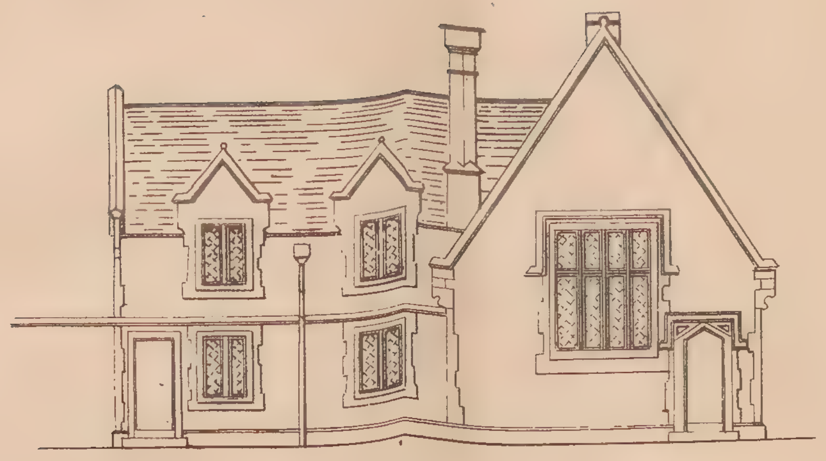


ELEVATION OF SCHOOL, PLAN IN Fig. 14.
ESSAY EIGHTH.

(3.)



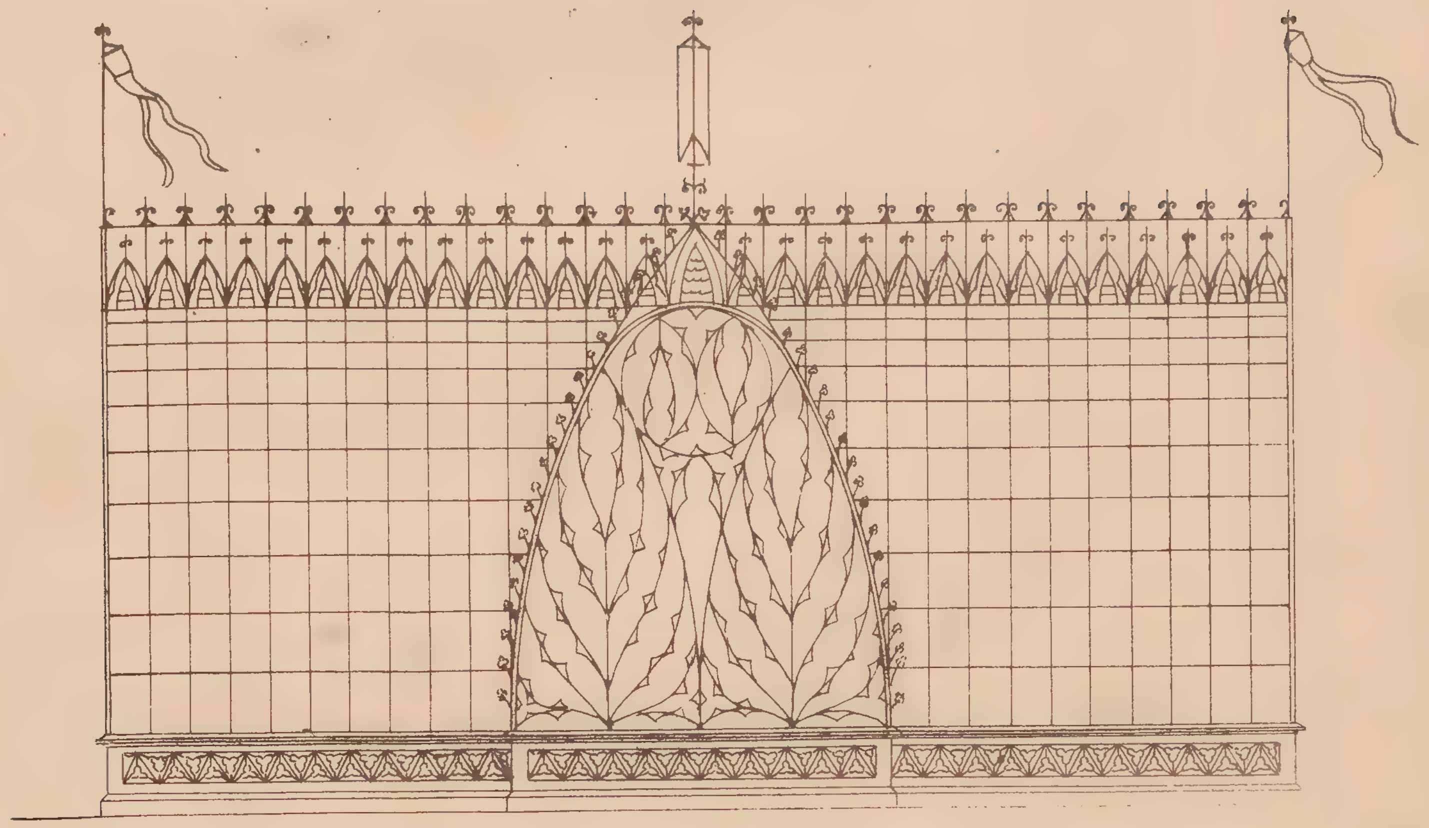
(8.)



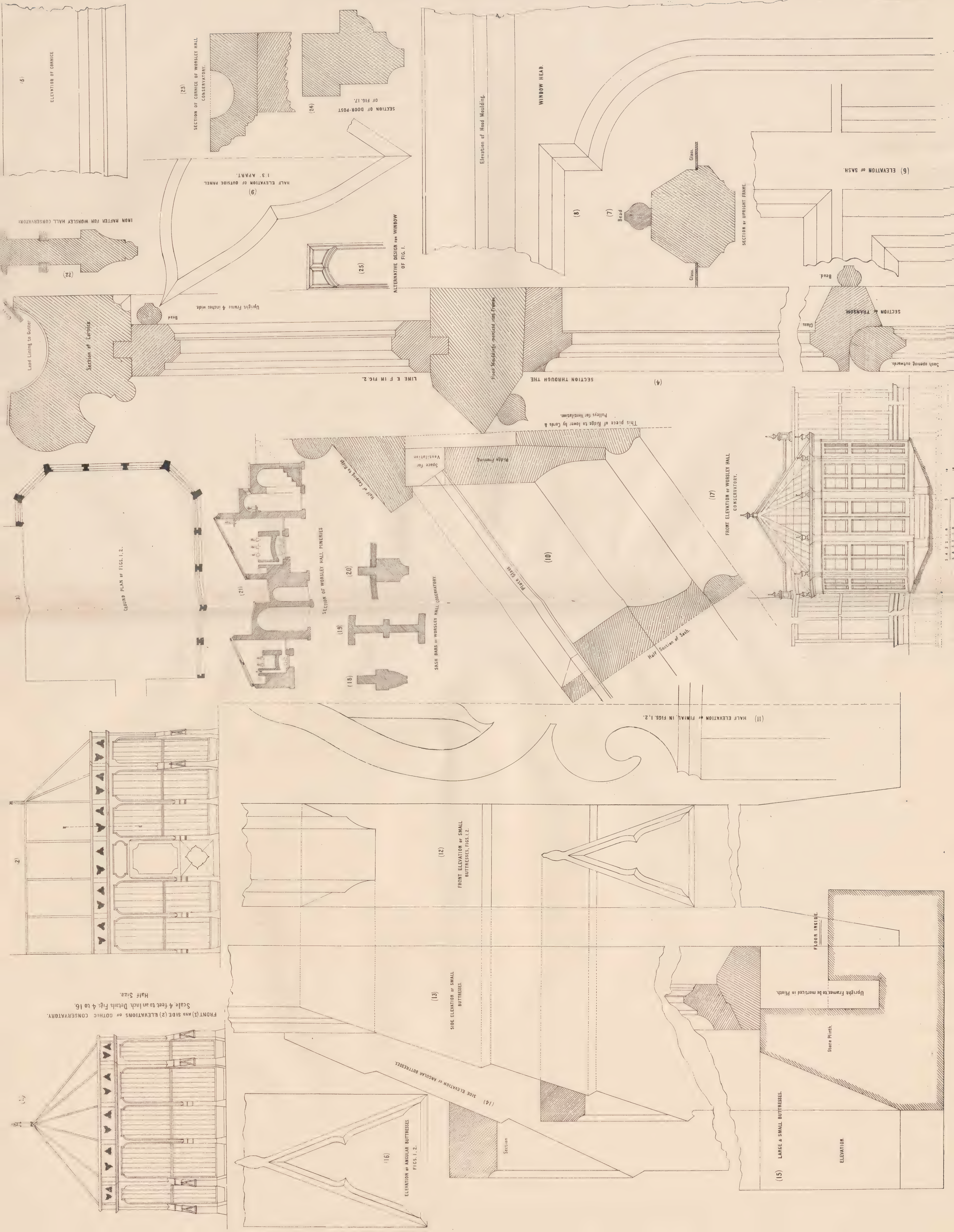
ELEVATION OF SCHOOL, PLAN IN Fig. 15.
ESSAY EIGHTH.

A. FULLARTON & CO., EDINBURGH AND LONDON.

(5.)



CONSERVATORY ELEVATIONS AND DETAILS.

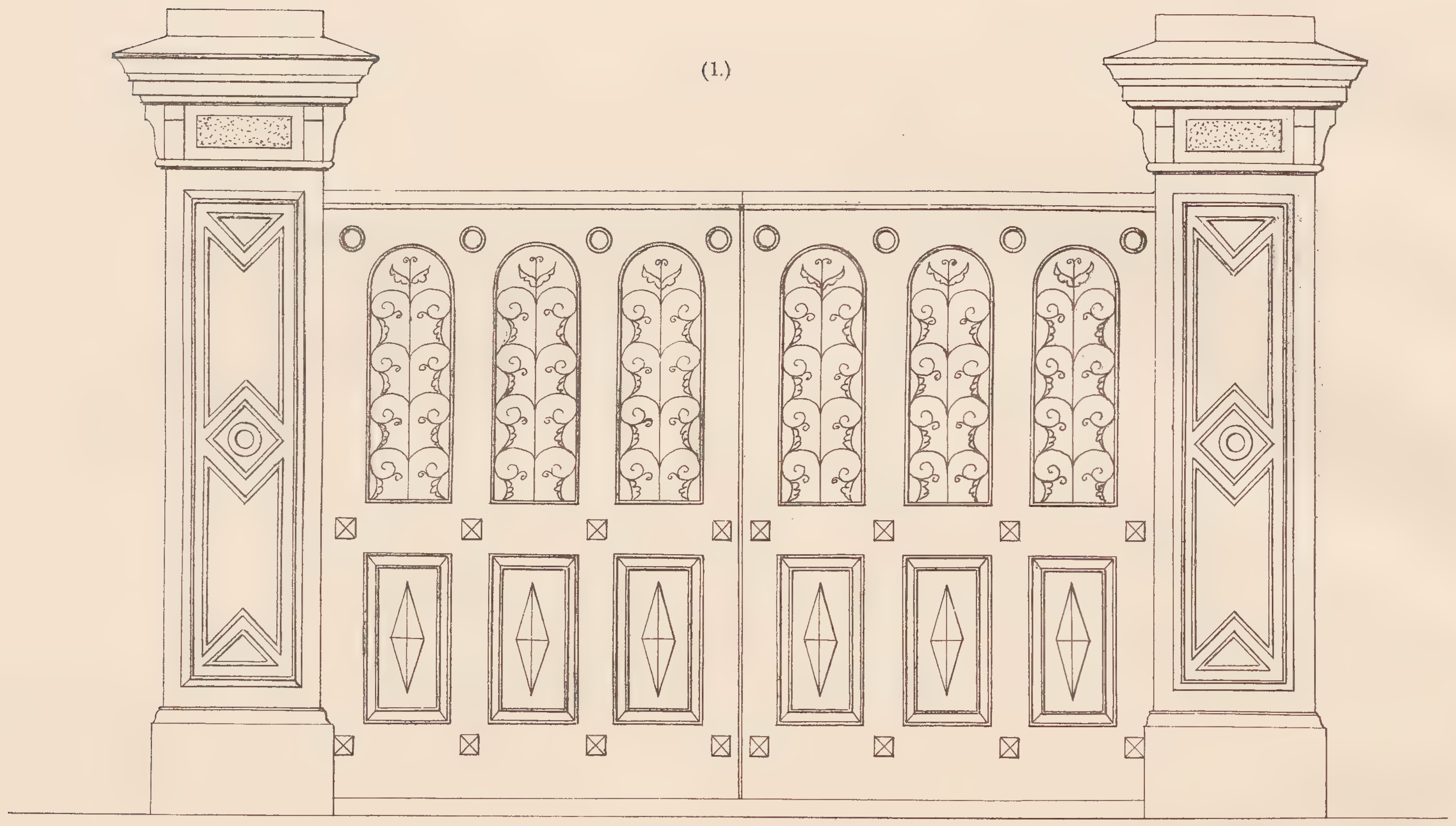

(5) ELEVATION OF CORNICE
(23) SECTION OF CORNICE OF WORSLEY HALL CONSERVATORY.
(24) SECTION OF DOOR-POST OF FIG. 17.
Elevation of Hood Moulding.
WINDOW HEAD.
(6) ELEVATION of SASH.
(9) HALF ELEVATION OF OUTSIDE PANEL 1·3″ APART.
(8)
(7) Bead
Glass.
Glass.
SECTION of UPRIGHT FRAME.
Bead.
SECTION of TRANSOM
Glass.
Sash opening outwards.
IRON RAFTER FOR WORSLEY HALL CONSERVATORY.
(22)
(25) ALTERNATIVE DESIGN for WINDOW OF FIG. 1.
Upright Frame 4 inches wide.
Bead
Lead Lining to Gutter
Section of Cornice
LINE E F IN FIG 2.
Hood Mouldings mortised into Frames
SECTION THROUGH THE
(4)
This piece of Ridge to lower by Cords & Pulleys for Ventilation.
Half of Capping to Ridge
Space for Ventilation
Ridge Framing
(10)
Plate Glass
Half Section of Sash.
(17) FRONT ELEVATION of WORSLEY HALL CONSERVATORY.
(3) GROUND PLAN of FIGS. 1, 2.
(21) SECTION OF WORSLEY HALL PINERIES
(20)
(19)
(18)
SASH BARS of WORSLEY HALL CONSERVATORY
(11) HALF ELEVATION of FINIAL IN FIGS. 1, 2.
(2)
(12) FRONT ELEVATION of SMALL BUTTRESSES, FIGS. 1, 2.
FLOOR INSIDE
Upright Frames to be mortised in Plinth.
Stone Plinth.
(13) SIDE ELEVATION of SMALL BUTTRESSES.
(14) SIDE ELEVATION of ANGULAR BUTTRESSES.
Section
(15) LARGE & SMALL BUTTRESSES.
ELEVATION.
(16) ELEVATION of ANGULAR BUTTRESSES FIGS. 1, 2.
(1)

FRONT (1) AND SIDE (2) ELEVATIONS OF GOTHIC CONSERVATORY.
Scale 4 feet to an Inch. Details Figs. 4 to 16.
Half Size.

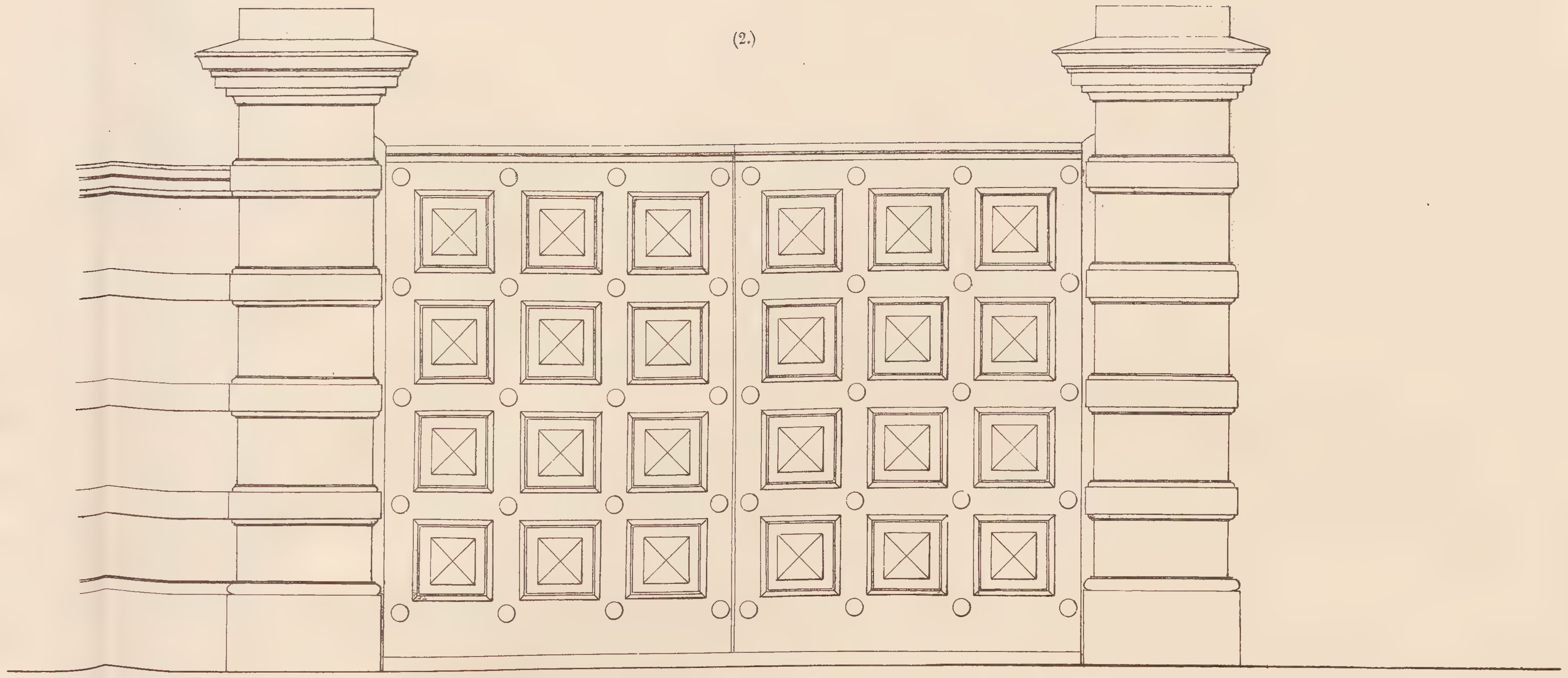
PLATE - XXII.

SUGGESTIONS FOR LODGE AND PARK GATES.

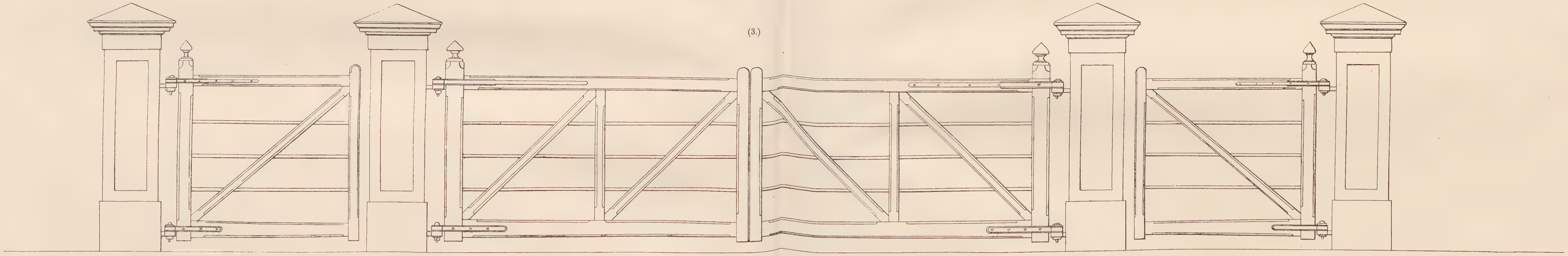
(1.)



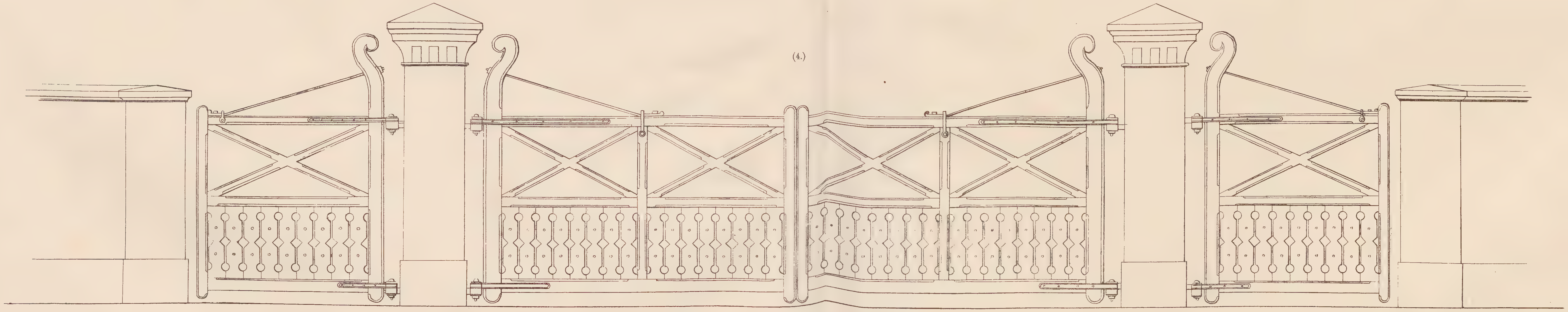
(2.)



(3.)



(4.)

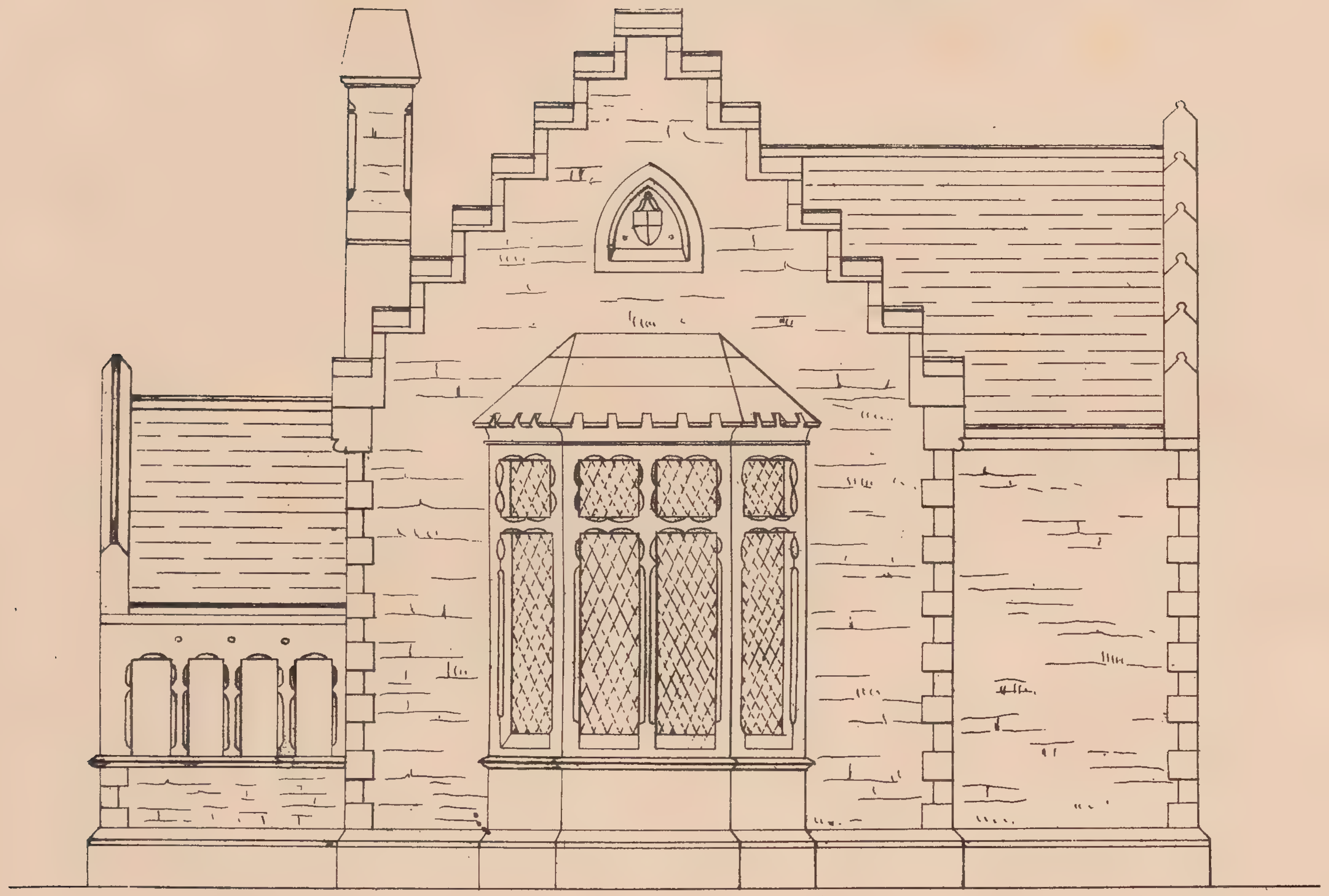


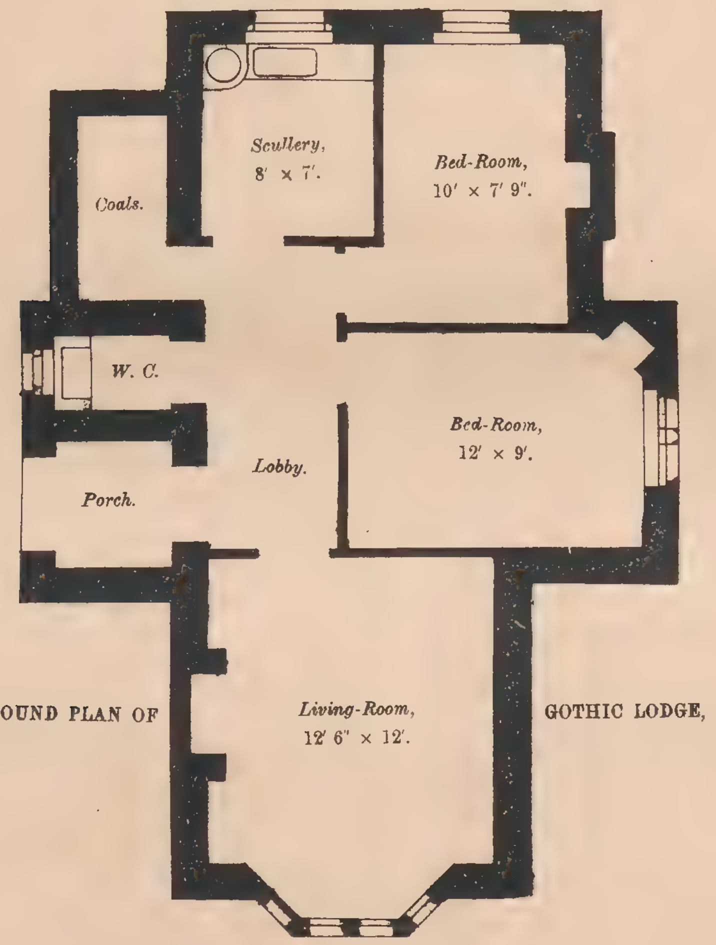
SCALE $\frac{1}{8}$ INCH TO THE FOOT.

SUGGESTIONS FOR ENTRANCE OR GATE LODGES.

(1.)

GOTHIC. RUBBLE, FREESTONE DRESSINGS.

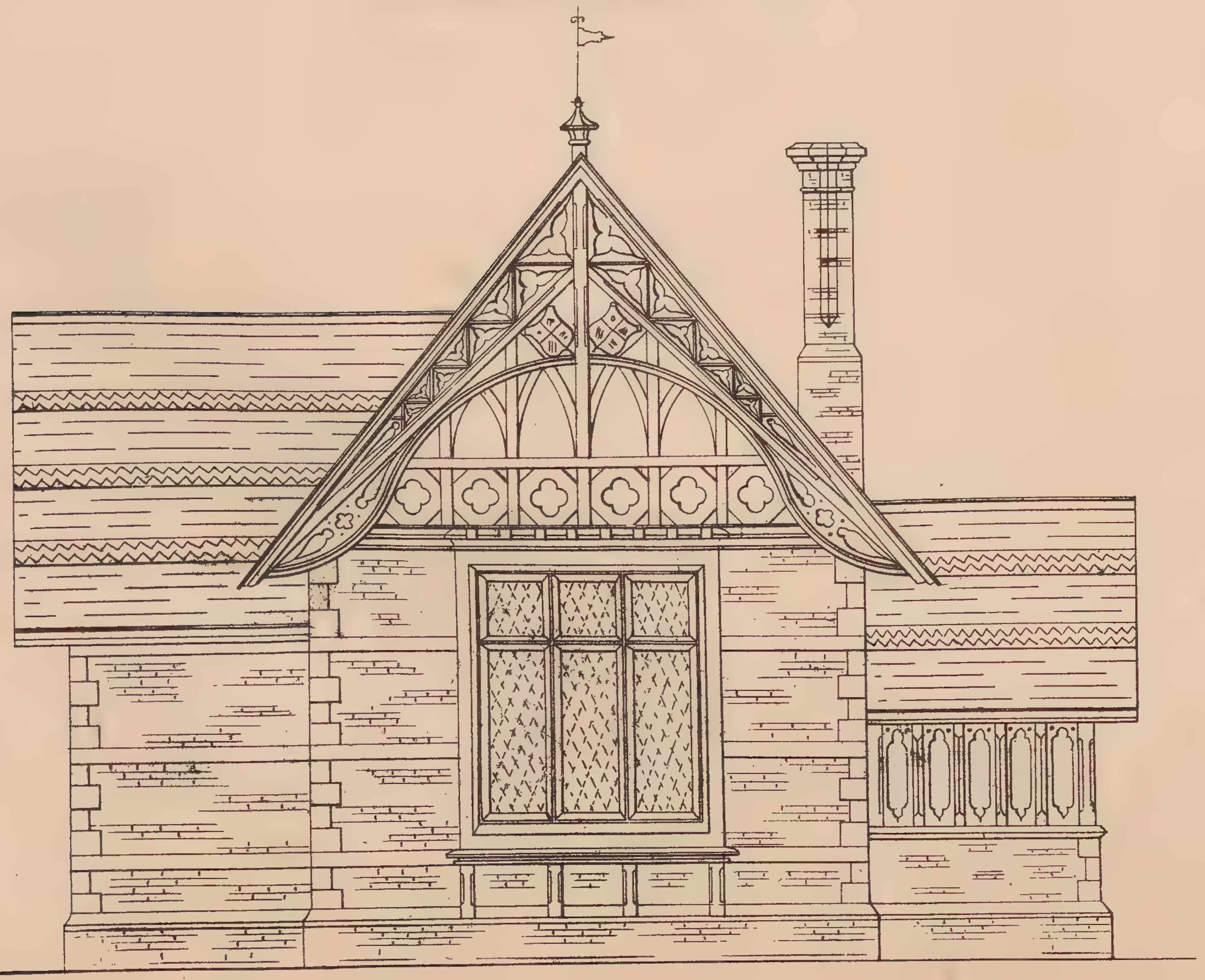


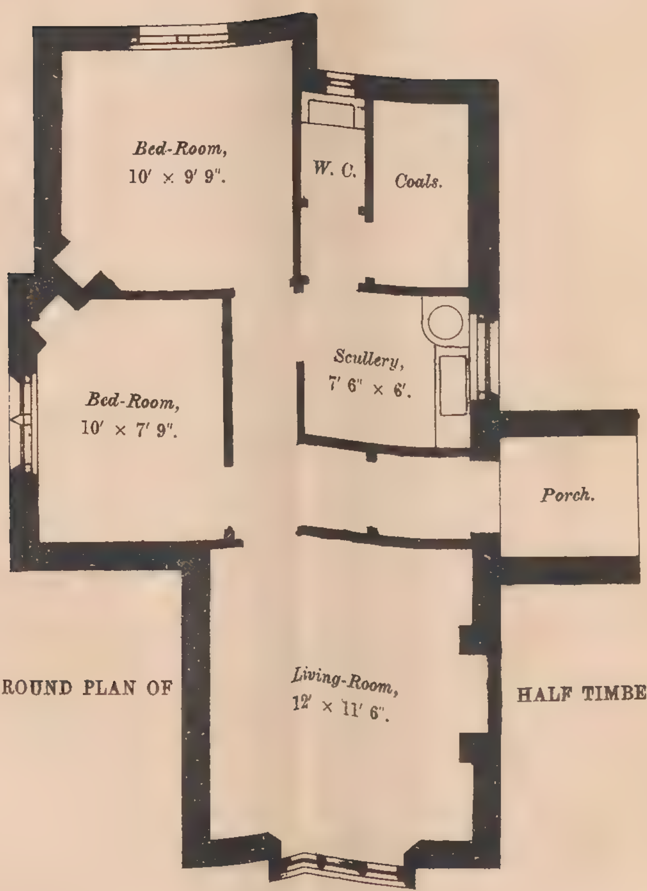

Scullery,
8' × 7'.
Coals.
Bed-Room,
10' × 7' 9".
W. C.
Lobby.
Bed-Room,
12' × 9'.
Porch.
Living-Room,
12' 6" × 12'.

GROUND PLAN OF GOTHIC LODGE, Fig. 1.

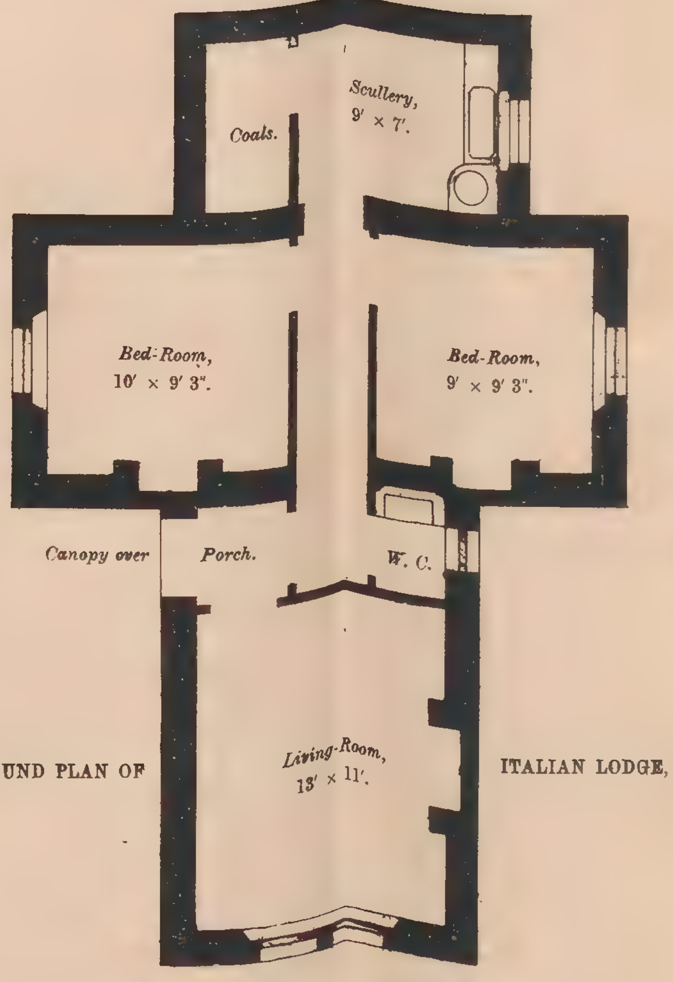
(2.)

GOTHIC (HALF TIMBERED). BRICK, FREESTONE DRESSINGS.




Bed-Room,
10' × 9' 9".
W. C.
Coals.
Bed-Room,
10' × 7' 9".
Scullery,
7' 6" × 6'.
Porch.
Living-Room,
12' × 11' 6".

GROUND PLAN OF HALF TIMBERED LODGE, Fig. 2.

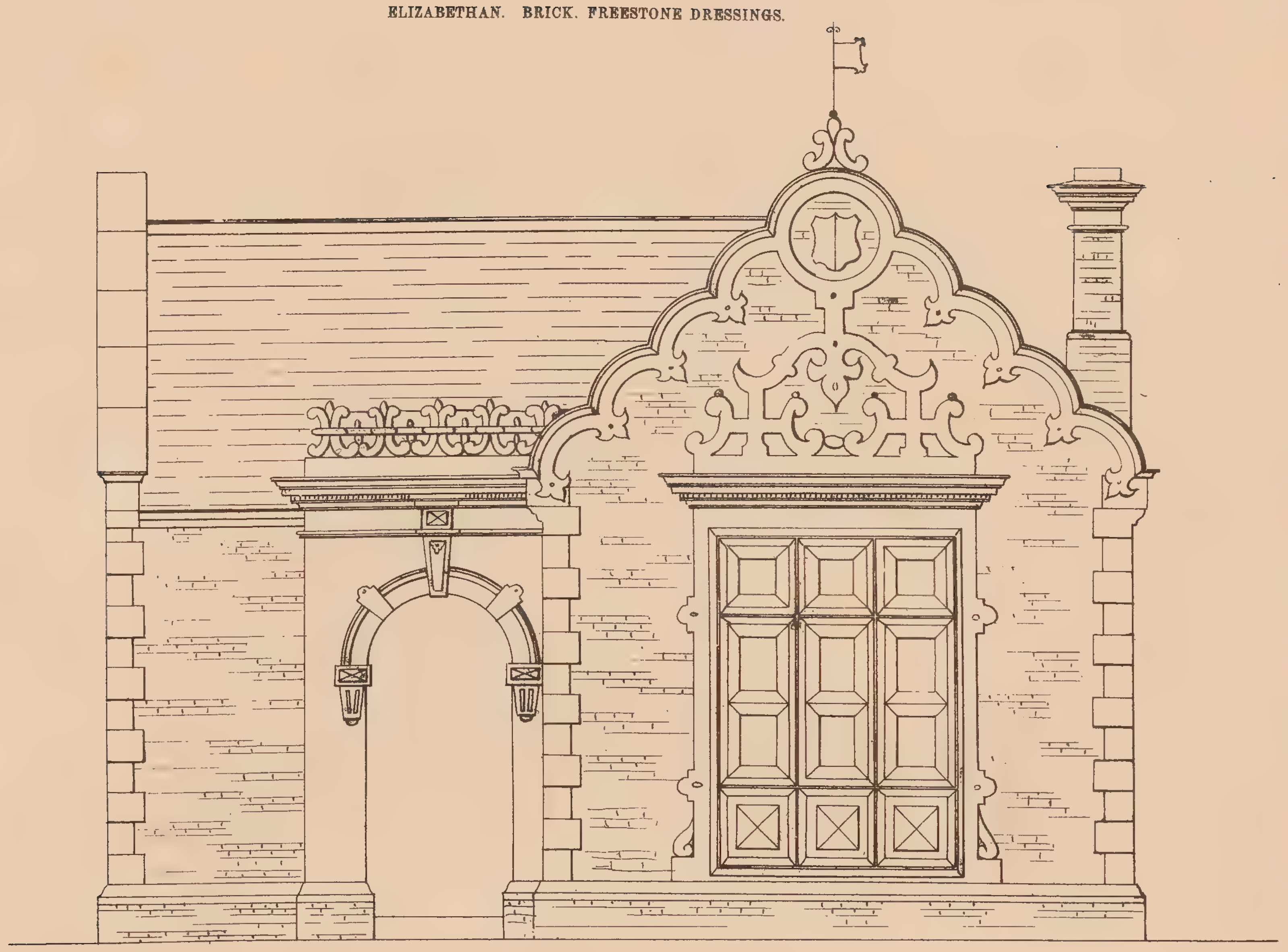

Coals.
Scullery,
9' × 7'.
Bed-Room,
10' × 9' 3".
Bed-Room,
9' × 9' 3".
Canopy over
Porch.
W. C.
Living-Room,
13' × 11'.

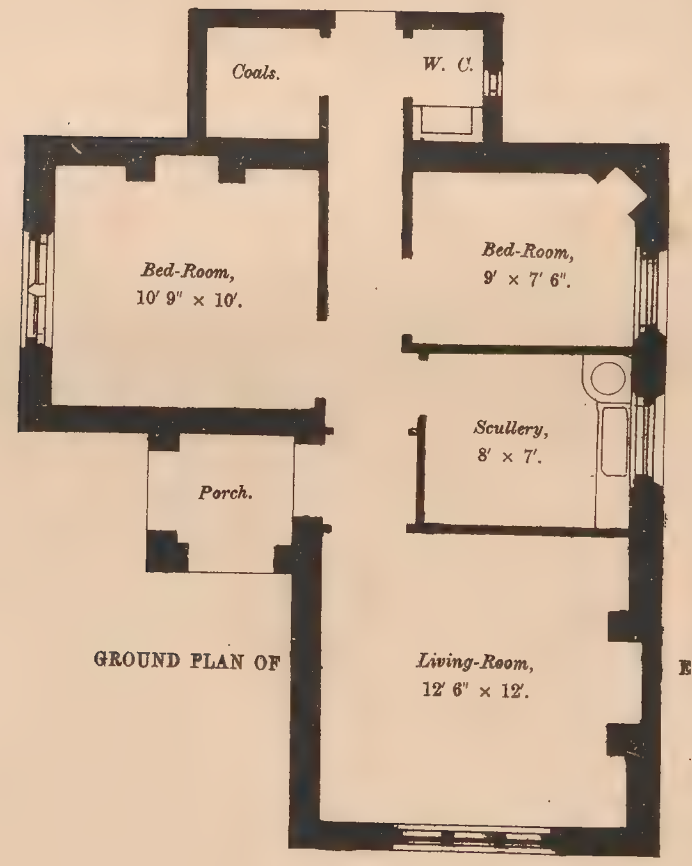
GROUND PLAN OF ITALIAN LODGE, Fig. 4.

SCALE FOR PLANS $\frac{1}{8}$TH OF AN INCH = 1 FOOT.
" " ELEVATIONS $\frac{1}{4}$TH " "

(3.)

ELIZABETHAN. BRICK. FREESTONE DRESSINGS.

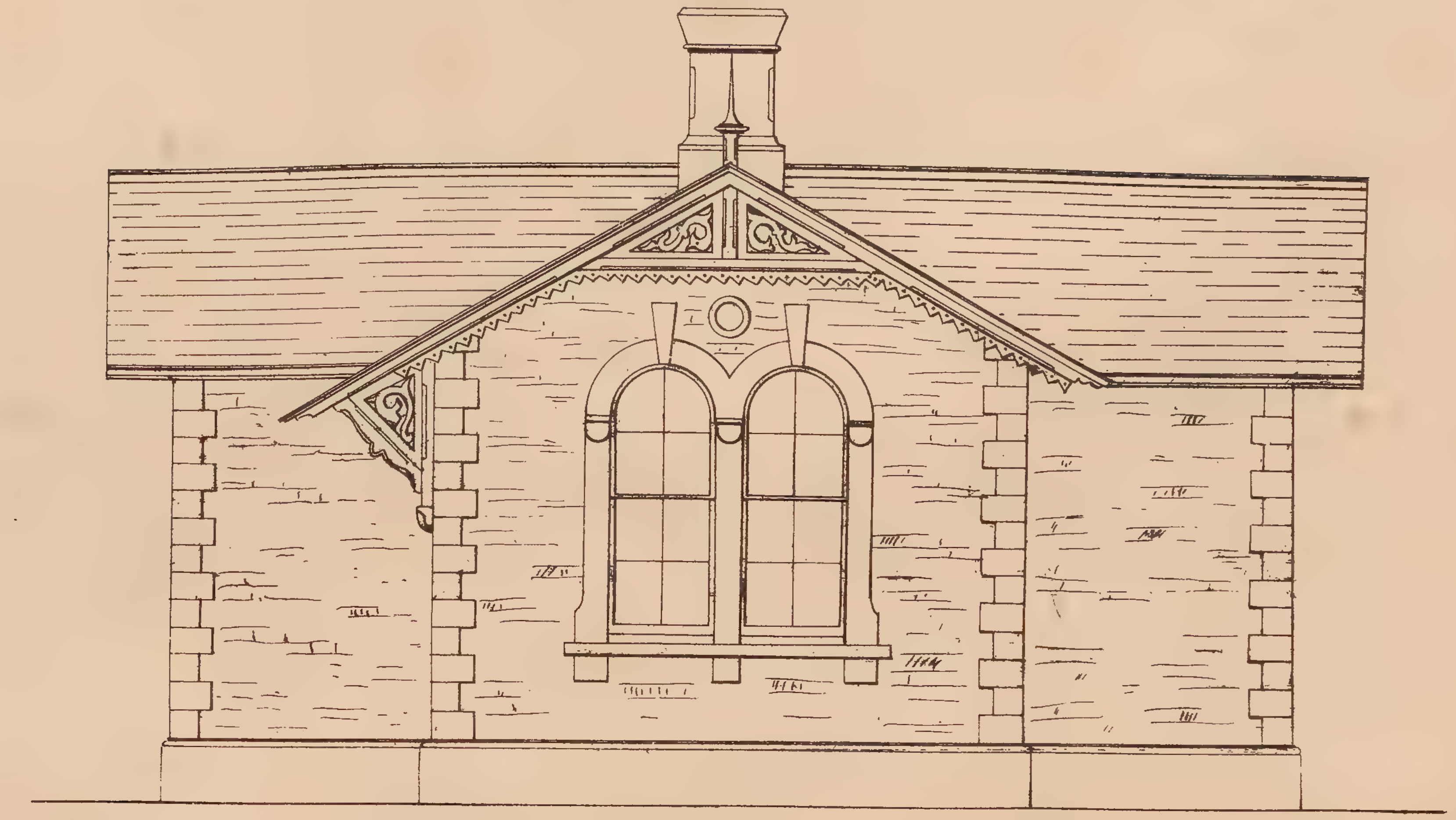



Coals.
W. C.
Bed-Room,
10' 9" × 10'.
Bed-Room,
9' × 7' 6".
Scullery,
8' × 7'.
Porch.
Living-Room,
12' 6" × 12'.

GROUND PLAN OF ELIZABETHAN LODGE, Fig. 3.

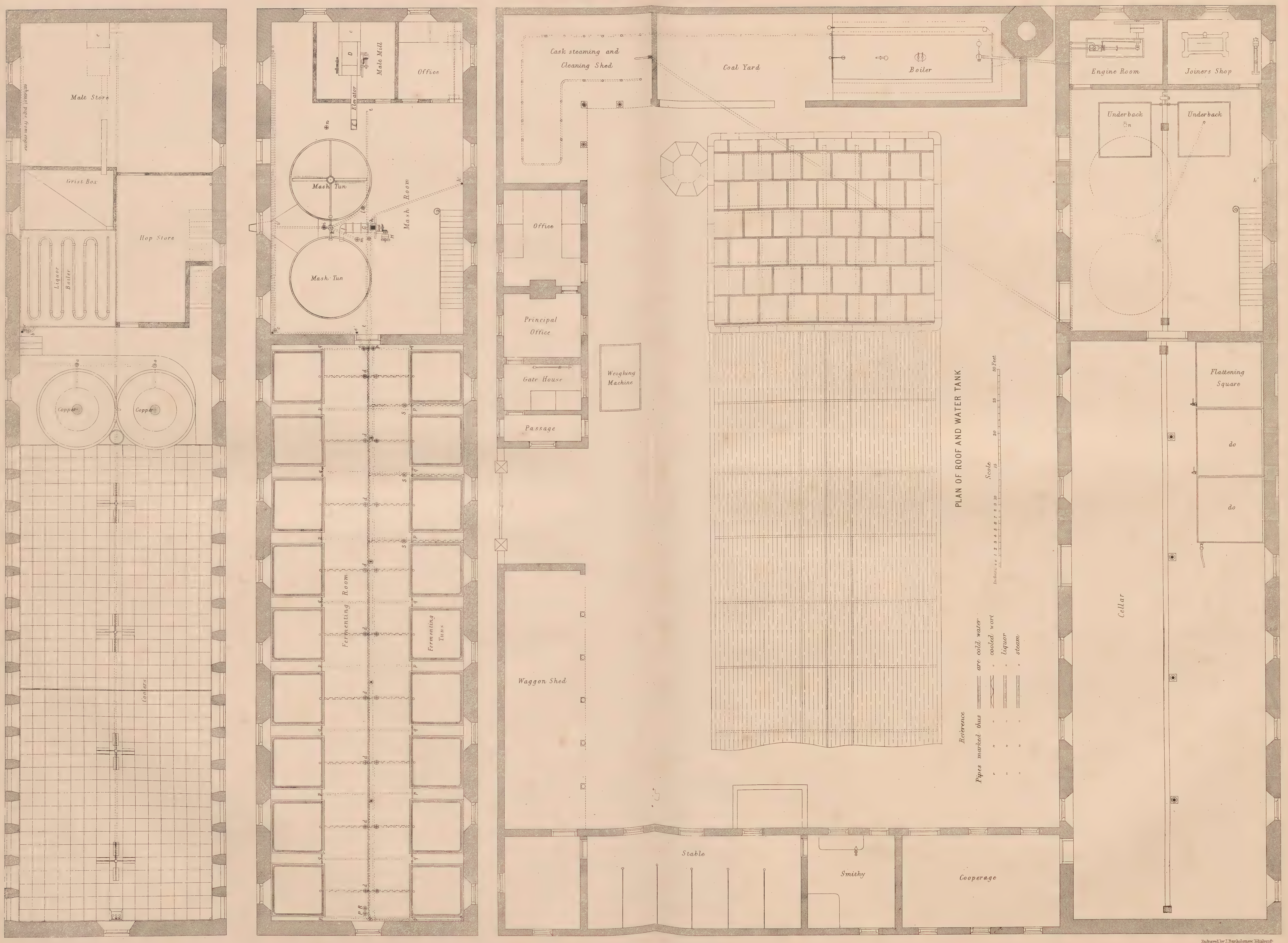
(4.)

ITALIAN. RUBBLE, FREESTONE DRESSINGS.



PLAN OF BREWERY.

PLATE XXIV.

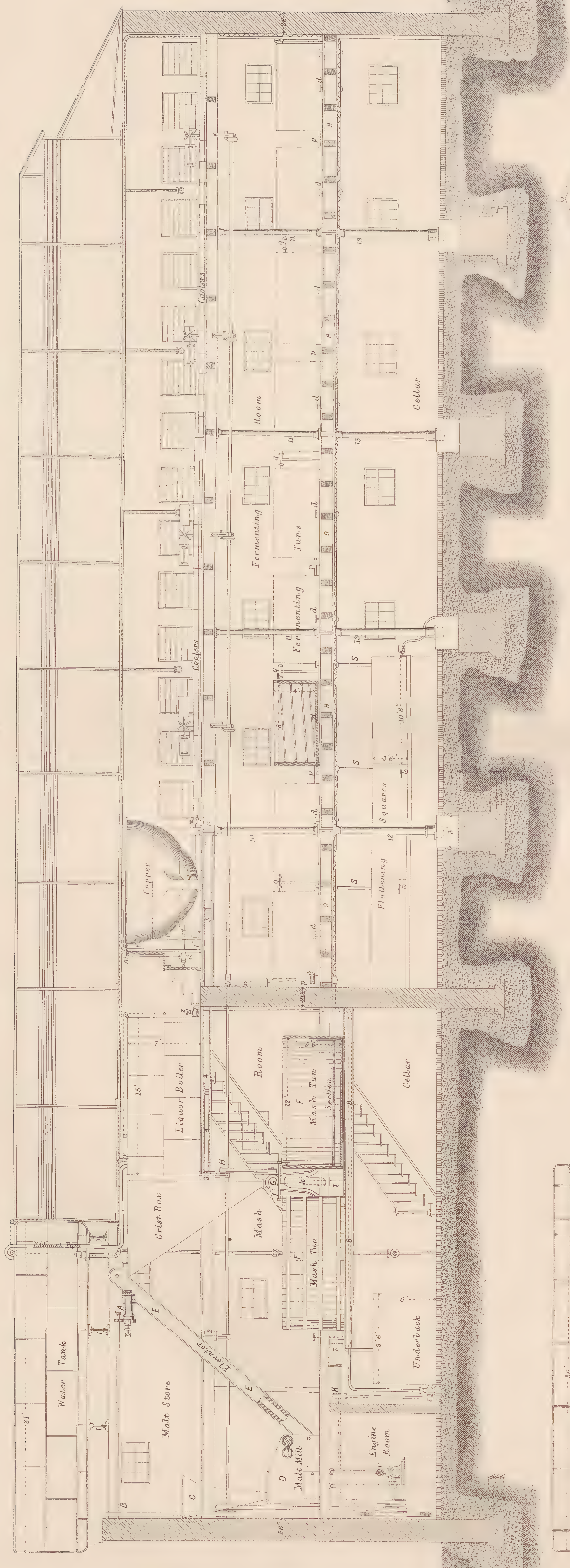

Malt Store
exhaust pipe from engine
Grist Box
Hop Store
Liquor Boiler
Copper
Copper
Coolers
Malt Mill
Office
Elevator
Mash Tun
Mash Tun
Mash Room
Fermenting Room
Fermenting Tuns
Cask steaming and Cleaning Shed
Coal Yard
Boiler
Engine Room
Joiners Shop
Underback
Underback
Office
Principal Office
Gate House
Passage
Weighing Machine
Waggon Shed
PLAN OF ROOF AND WATER TANK
Scale
Inches 12 1 2 3 4 5 6 7 8 9 10 15 20 25 30 Feet
Reference
Pipes marked thus are cold water
" " " cooled wort
" " " liquor
" " " steam
Flattening Square
do
do
Cellar
GROUND PLAN
Stable
Smithy
Cooperage

A. FULLARTON & CO. LONDON AND EDINBURGH.

Engraved by J. Bartholomew Edinburgh

SECTION OF BREWERY.

PLATE XXV.



Water Tank
31
Exhaust Pipe
Malt Store
Elevator
Malt Mill
Grist Box
Mash Room
Mash Tun
Mash Tun Section
Liquor Boiler
Room
Cellar
Underback
Engine Room
Copper
Flattening Squares
Fermenting Tuns
Fermenting Room
Coolers
Cellar
A
B
C
D
E
F
G
H
I
K
26

LONGITUDINAL SECTION

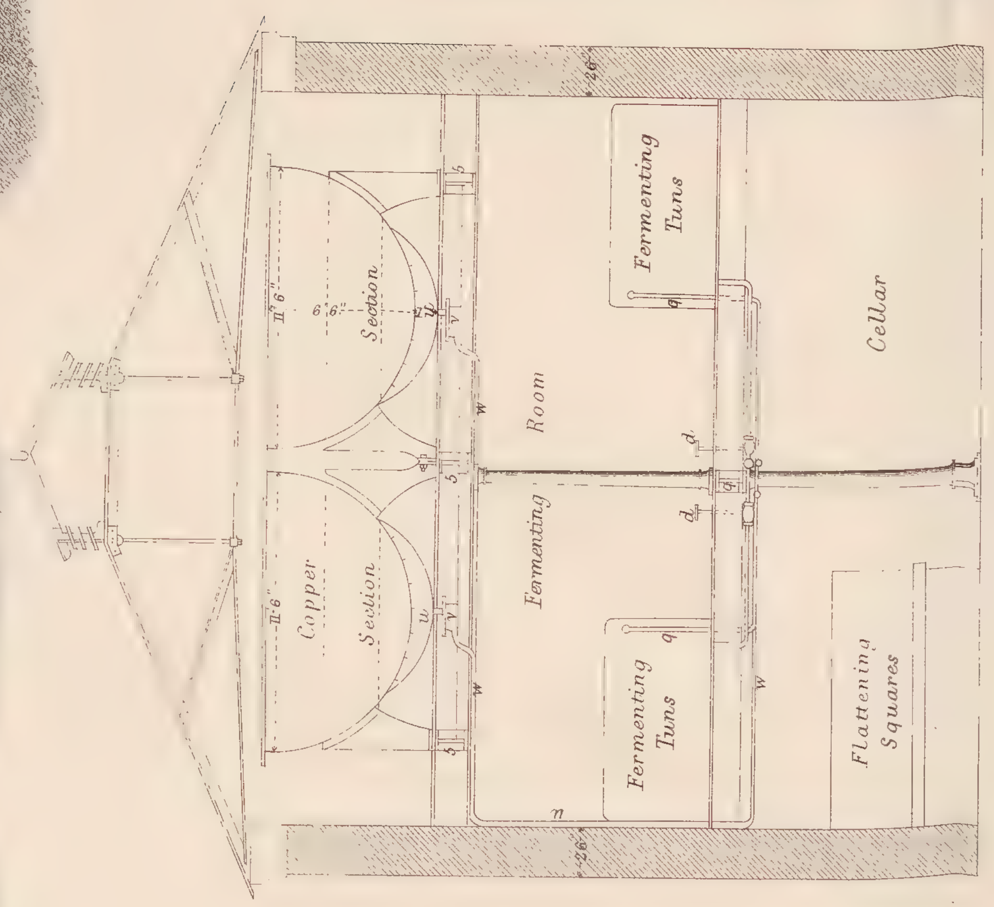
Reference

Pipes marked thus ═ are cold water

" ═ cooled wort

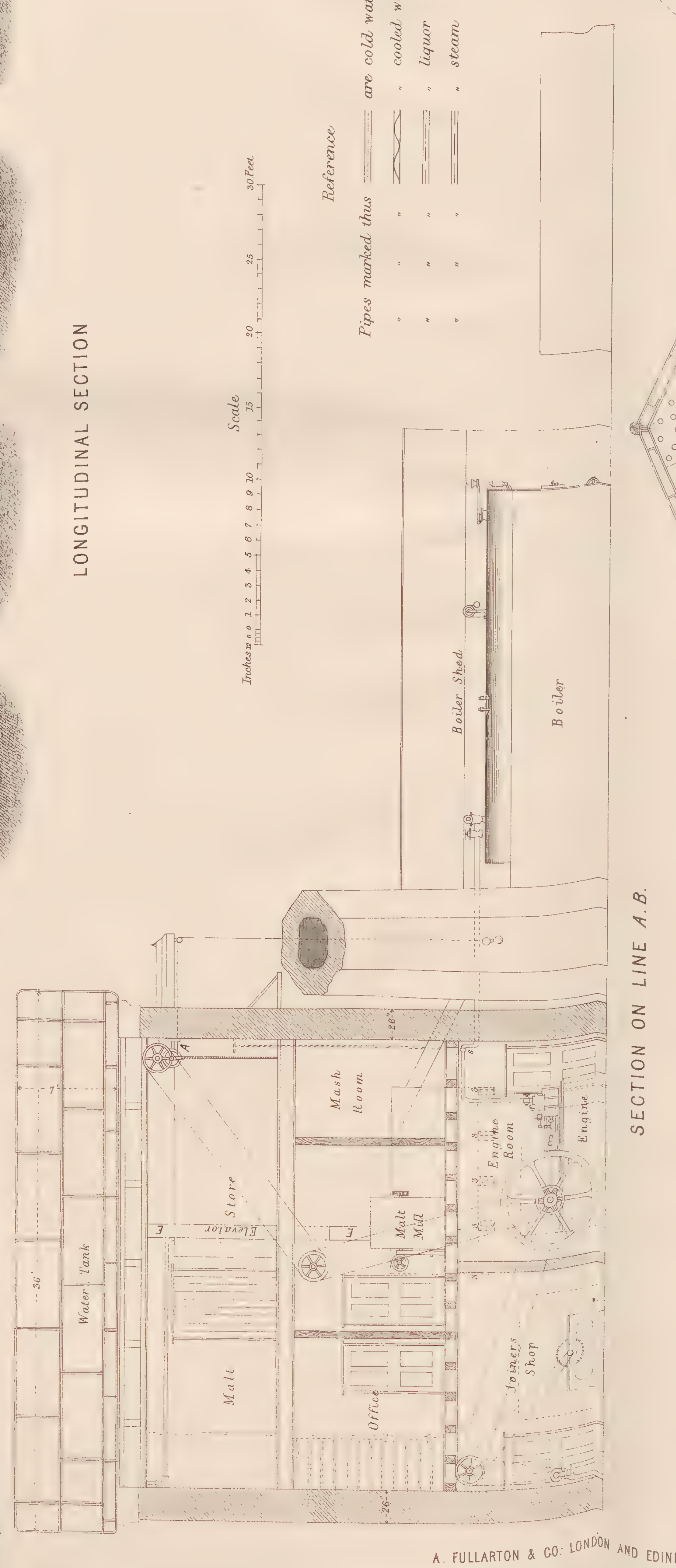
" ═ liquor

" ═ steam



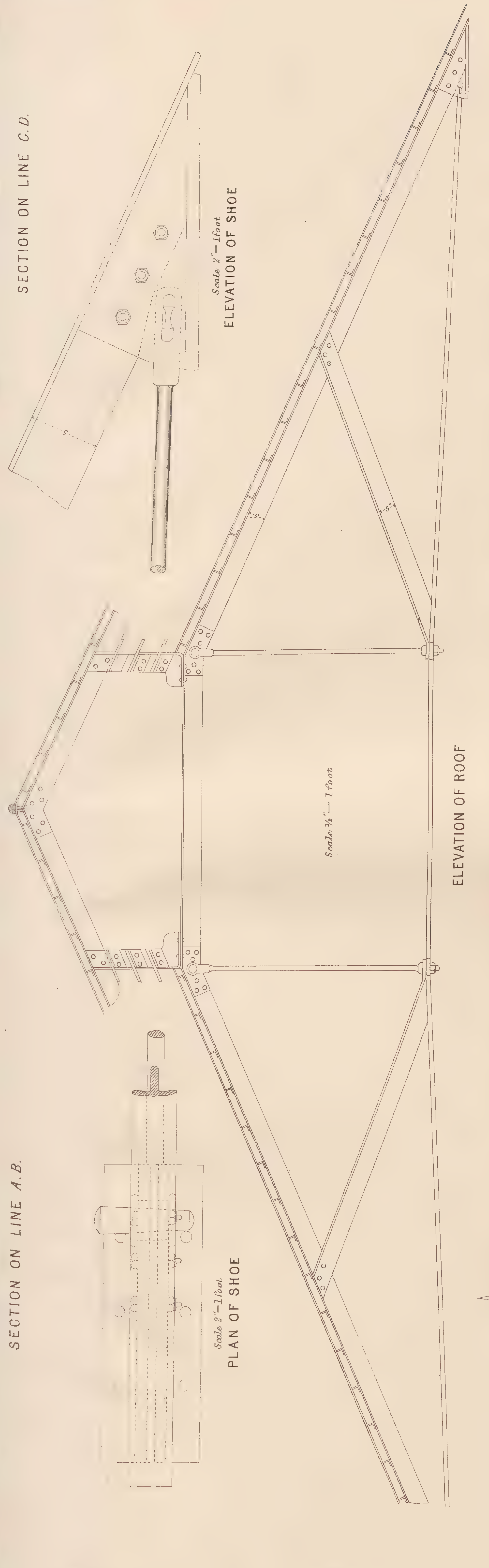
Copper Section
Fermenting Room
Fermenting Tuns
Cellar
Flattening Squares
26

SECTION ON LINE C.D.



Scale
Inches 12 9 6 3 0 1 2 3 4 5 6 7 8 9 10 15 20 25 30 Feet
Boiler Shed
Boiler
Water Tank
Malt
Store
Elevator
Malt Mill
Office
Mash Room
Engine Room
Engine
Joiners Shop
26

SECTION ON LINE A.B.

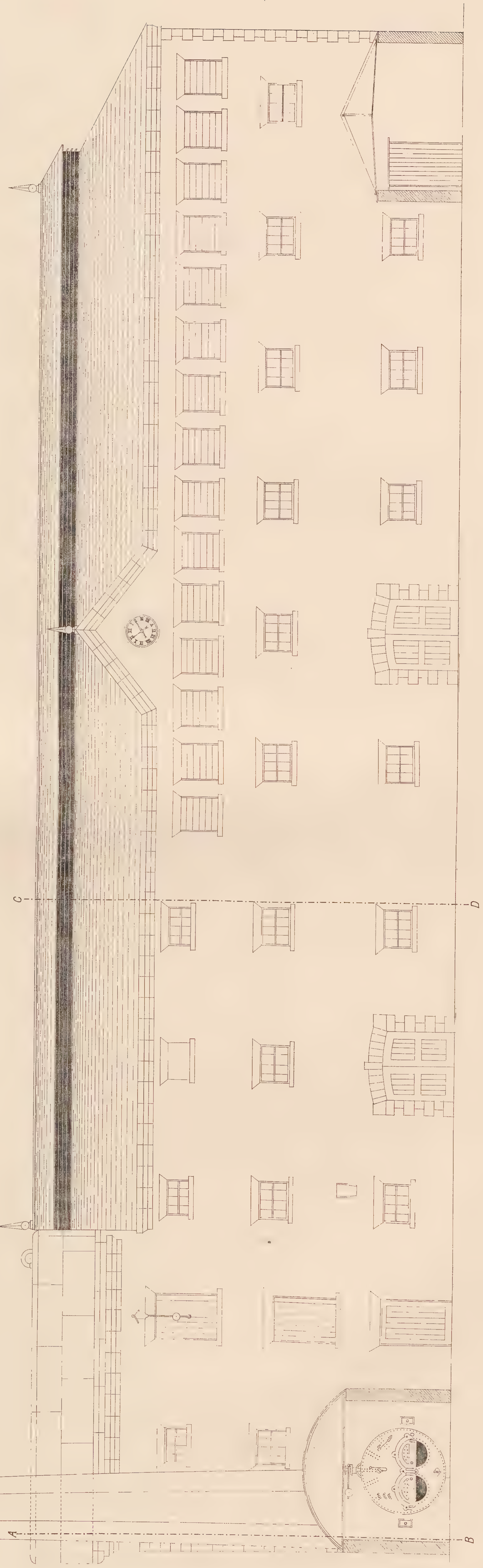


Scale 2" = 1 Foot
Scale ½" = 1 Foot
Scale 2" = 1 Foot

ELEVATION OF SHOE

ELEVATION OF ROOF

PLAN OF SHOE

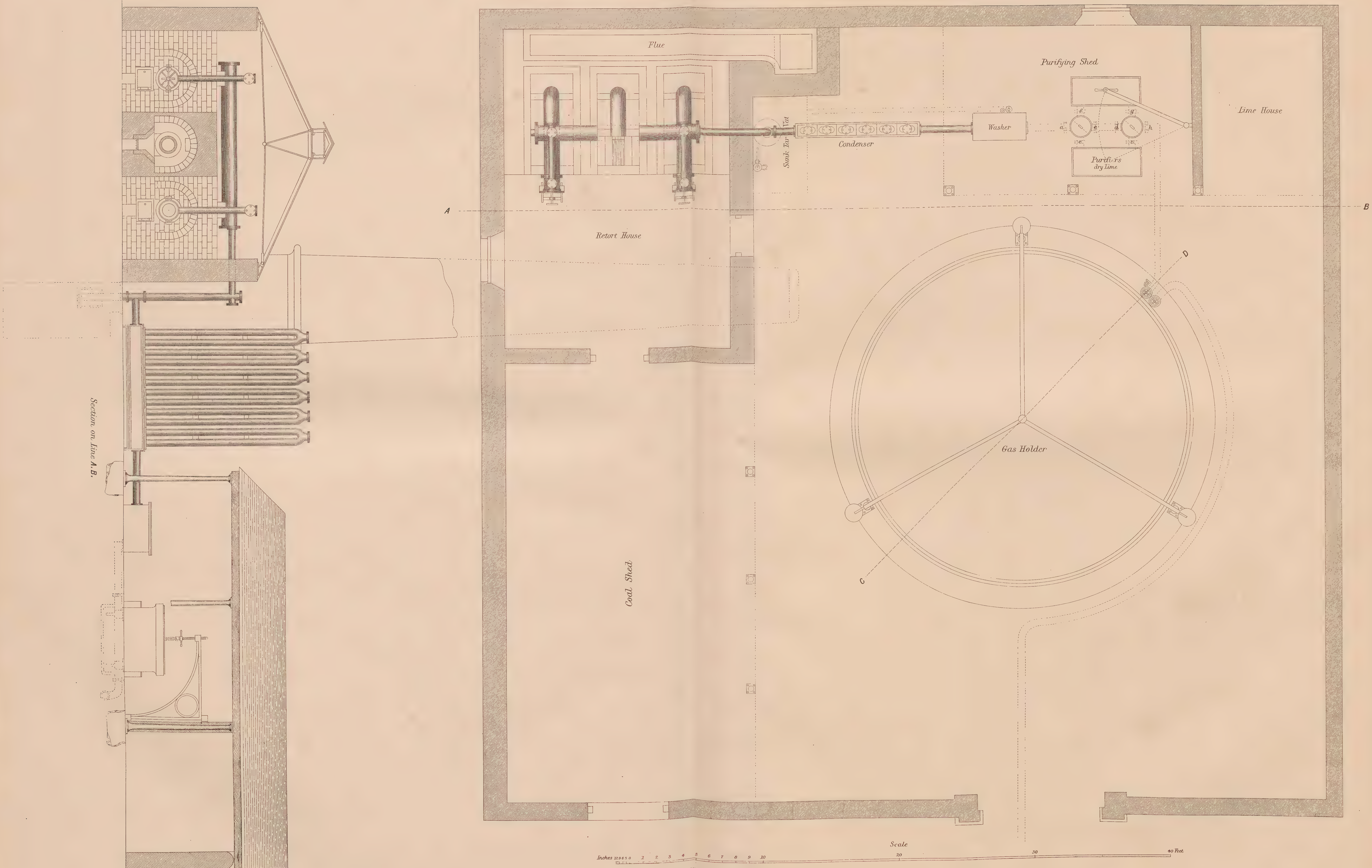


FRONT ELEVATION OF ALE BREWERY.

A. FULLARTON & Co. LONDON AND EDINBURGH.

Engraved by J. Bartholomew, Edinburgh

PLAN AND SECTION OF A THREE RETORT GAS WORK.

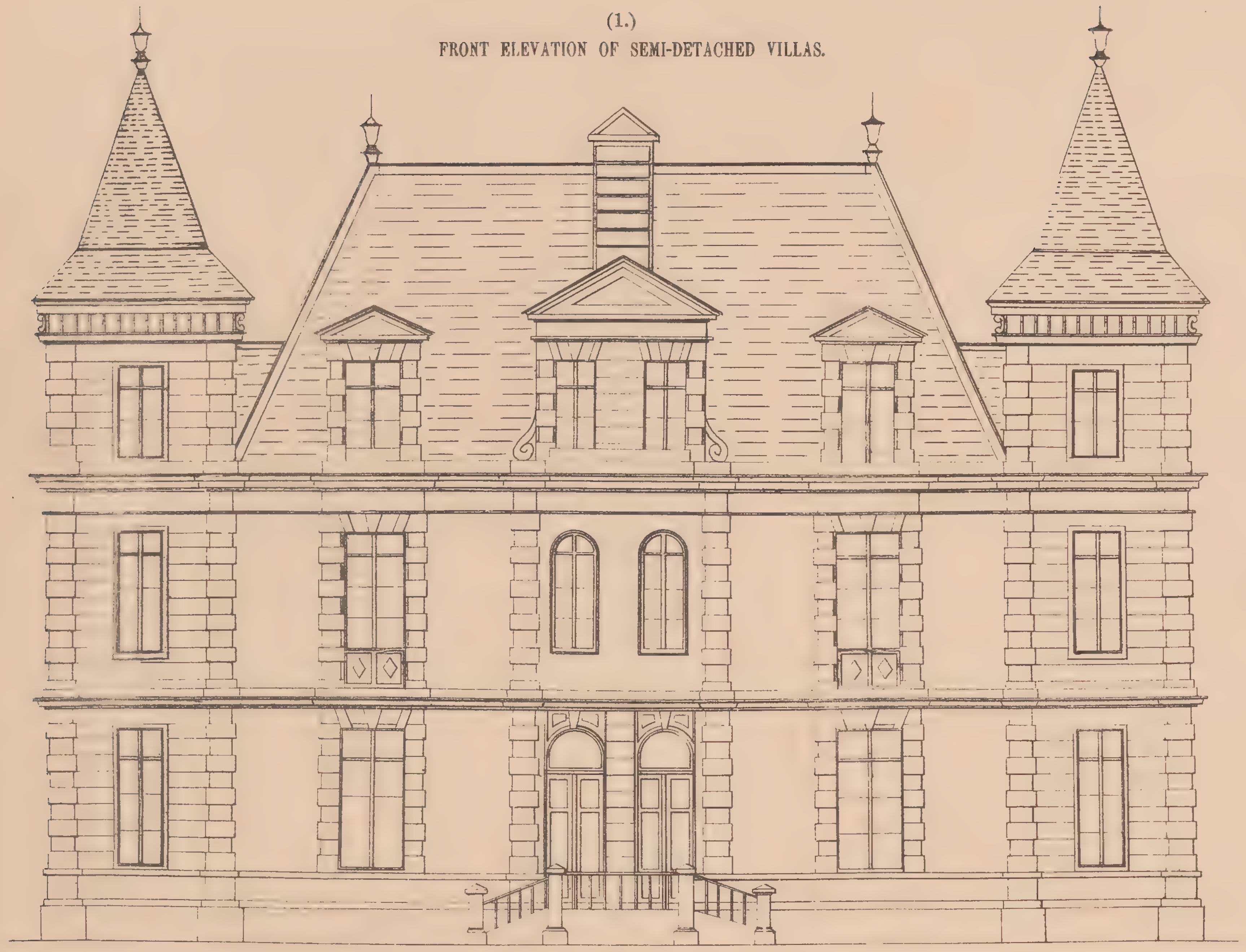

Section on Line A.B.
Flue
Purifying Shed
Lime House
Sunk Tar Vat
Condenser
Washer
a
e
d
h
f
g
e
e
Purifiers
dry Lime
A
B
Retort House
D
Gas Holder
C
Coal Shed
Scale
Inches 12 9 6 3 0 1 2 3 4 5 6 7 8 9 10 20 30 40 Feet

A FULLARTON & CO. LONDON AND EDINBURGH

SUGGESTIONS FOR VILLA PLANS WITH ELEVATIONS IN CONTINENTAL STYLES.

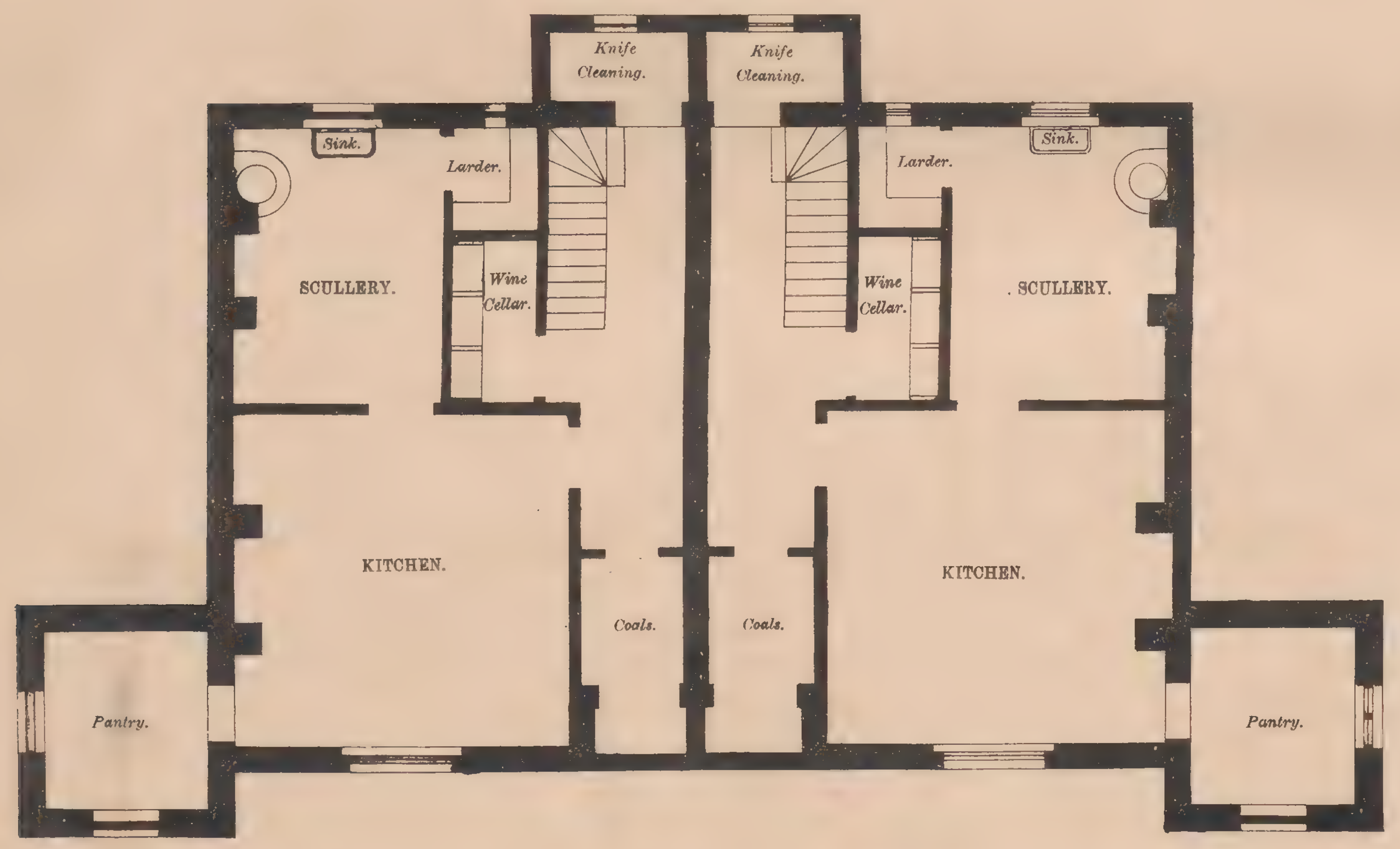
(1.)

FRONT ELEVATION OF SEMI-DETACHED VILLAS.

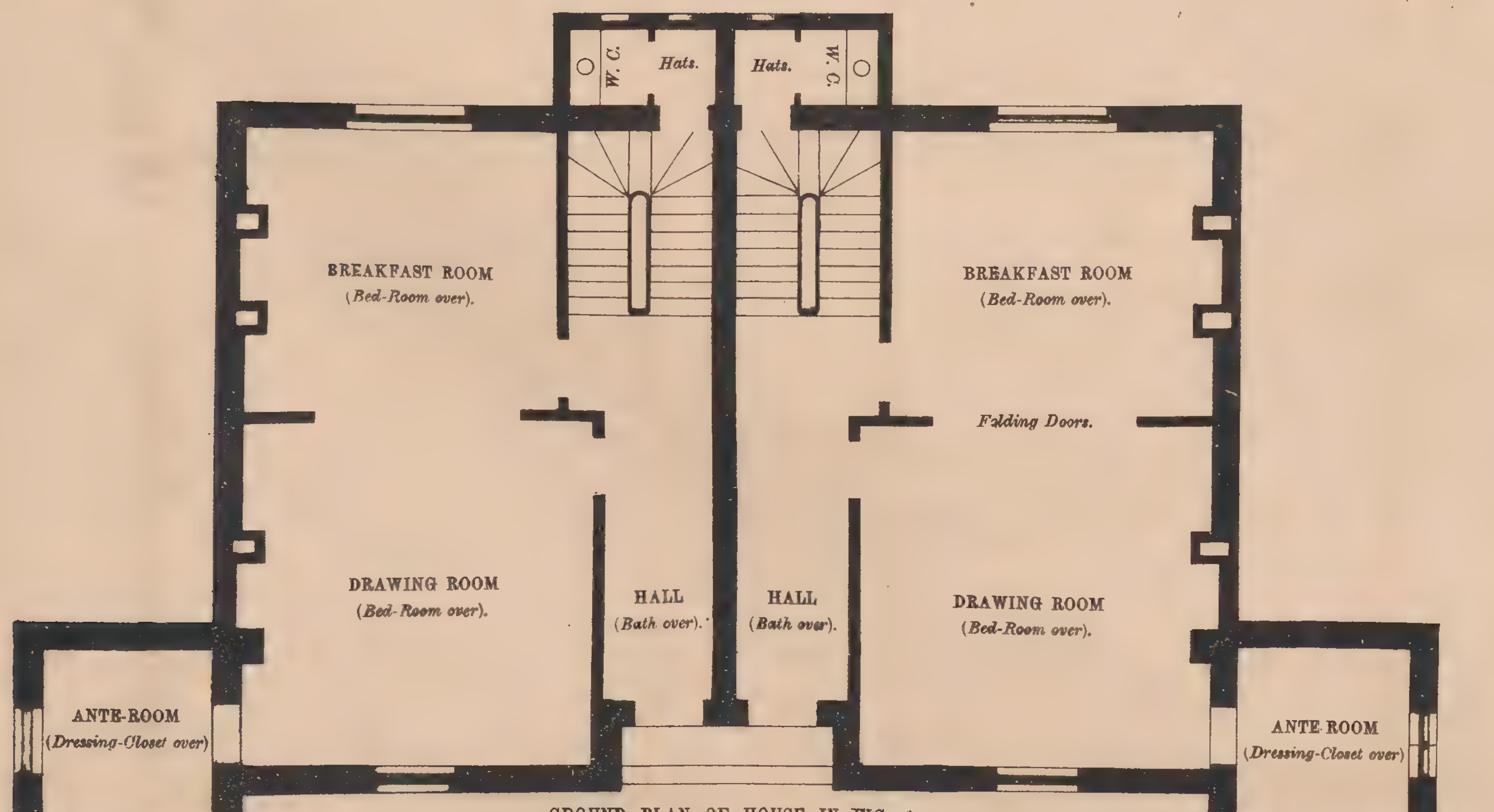


(2.)

BASEMENT PLAN OF HOUSE IN FIG. 1.


Knife Cleaning.
Knife Cleaning.
Sink.
Larder.
Larder.
Sink.
SCULLERY.
Wine Cellar.
Wine Cellar.
SCULLERY.
KITCHEN.
Coals.
Coals.
KITCHEN.
Pantry.
Pantry.

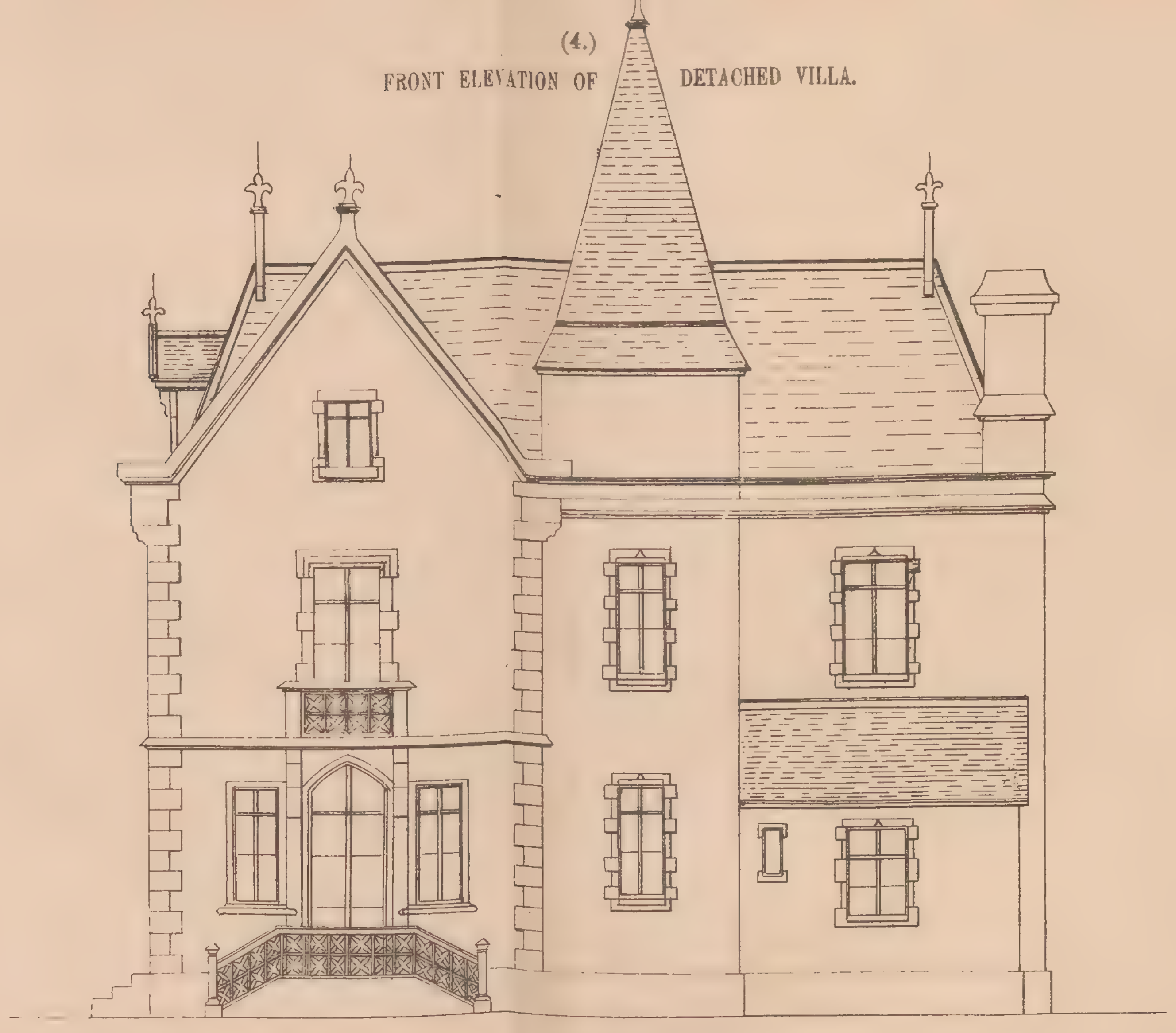
(3.)

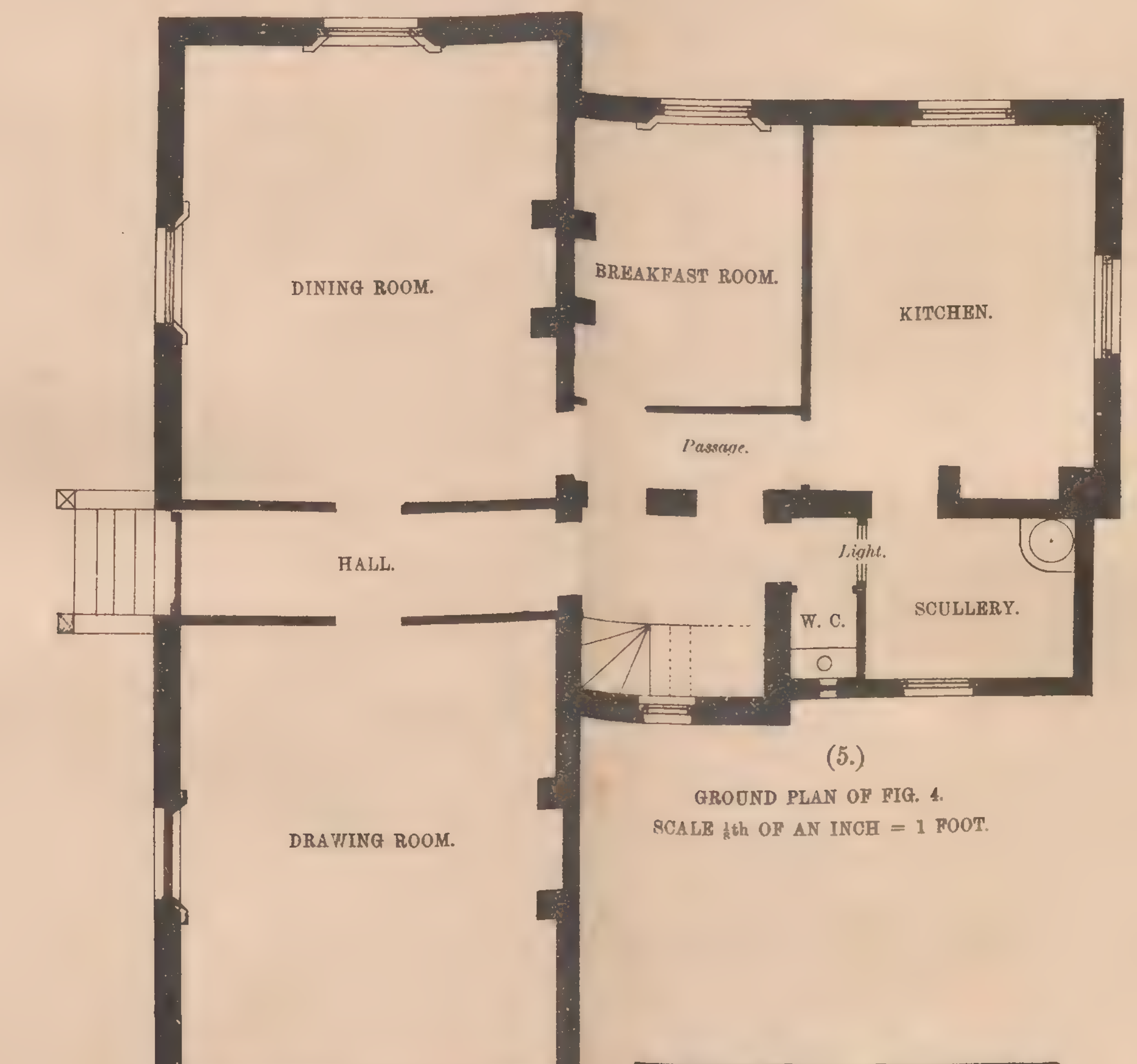

W. C.
Hats.
Hats.
W. C.
BREAKFAST ROOM (Bed-Room over).
BREAKFAST ROOM (Bed-Room over).
Folding Doors.
DRAWING ROOM (Bed-Room over).
HALL (Bath over).
HALL (Bath over).
DRAWING ROOM (Bed-Room over).
ANTE-ROOM (Dressing-Closet over)
ANTE ROOM (Dressing-Closet over)

GROUND PLAN OF HOUSE IN FIG. 1.
SCALE ¼th OF AN INCH = 1 FOOT.

(4.)

FRONT ELEVATION OF DETACHED VILLA.



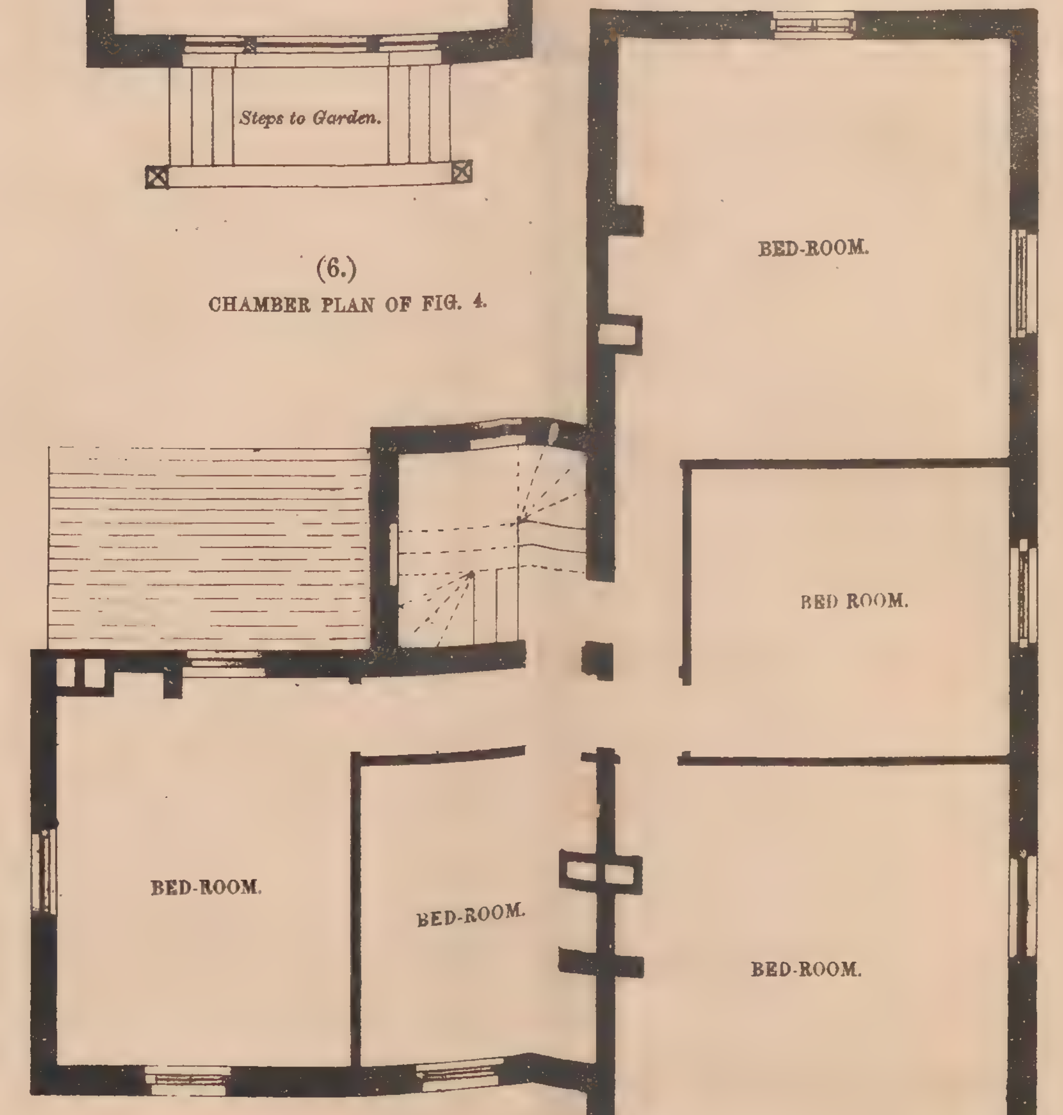

DINING ROOM.
BREAKFAST ROOM.
KITCHEN.
Passage.
HALL.
Light.
W. C.
SCULLERY.
DRAWING ROOM.
Steps to Garden.

(5.)

GROUND PLAN OF FIG. 4.
SCALE ¼th OF AN INCH = 1 FOOT.

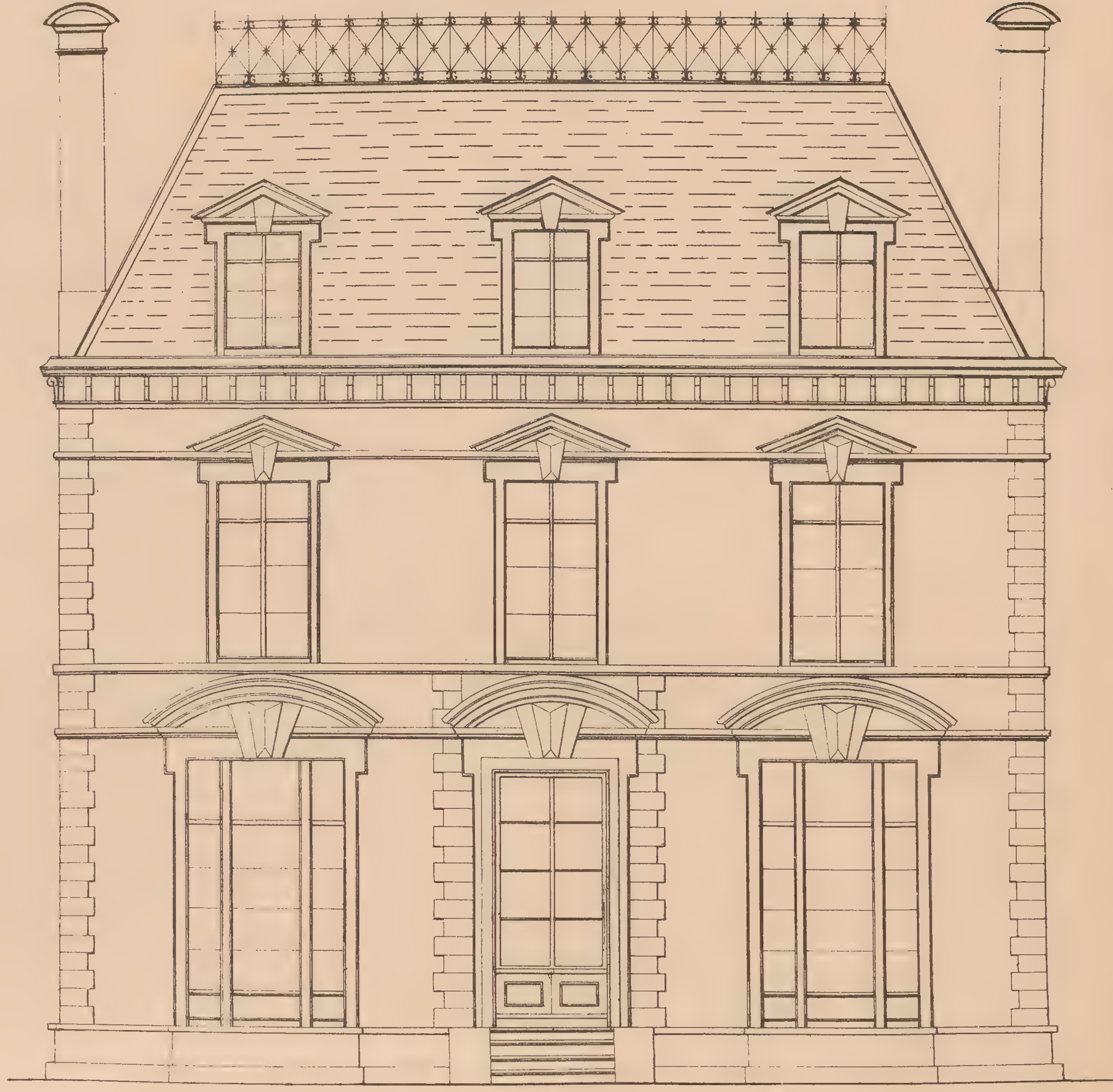
(6.)

CHAMBER PLAN OF FIG. 4.

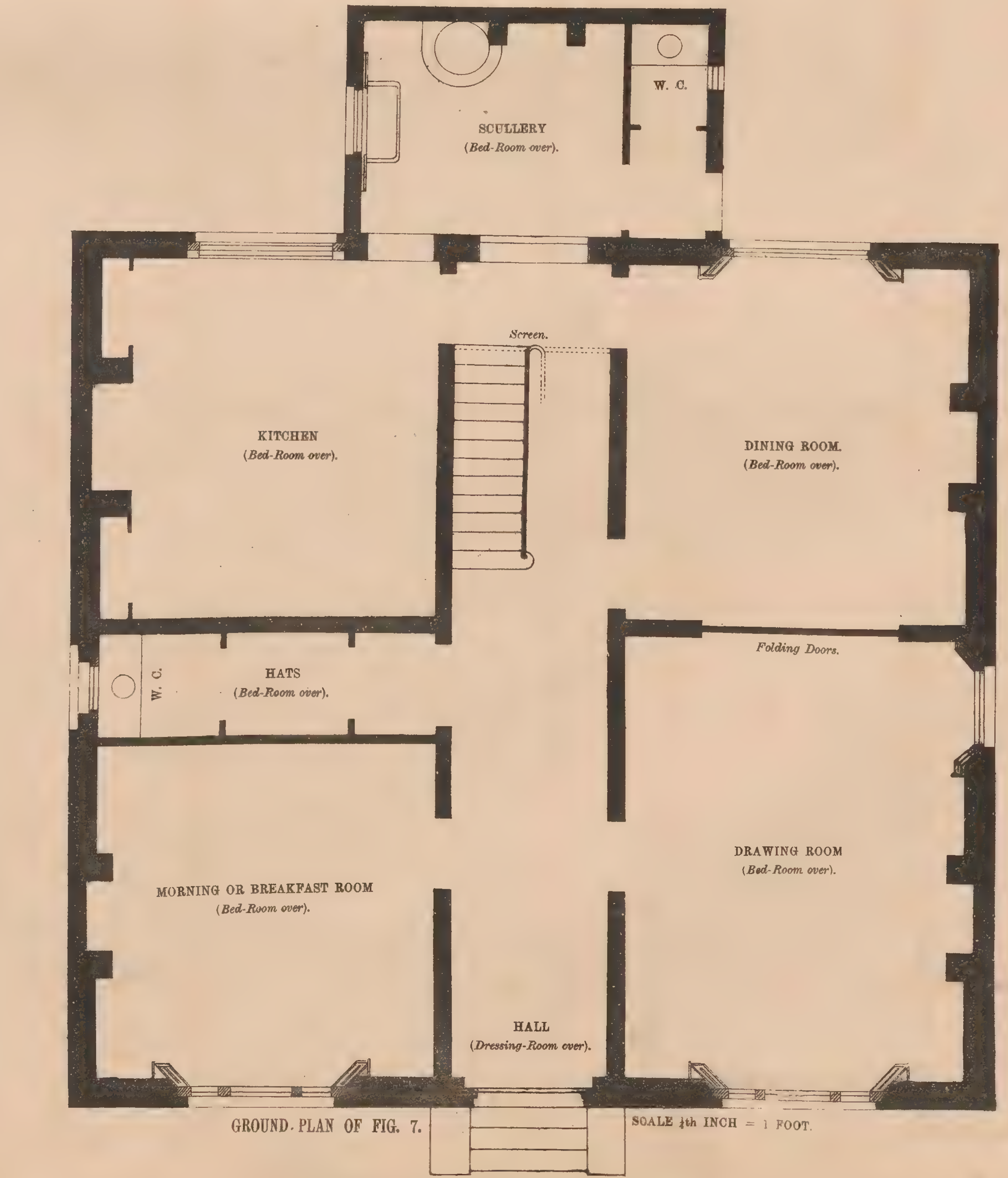

BED-ROOM.
BED ROOM.
BED-ROOM.
BED-ROOM.
BED-ROOM.

(7.)

FRONT ELEVATION OF DETACHED VILLA.



(8.)

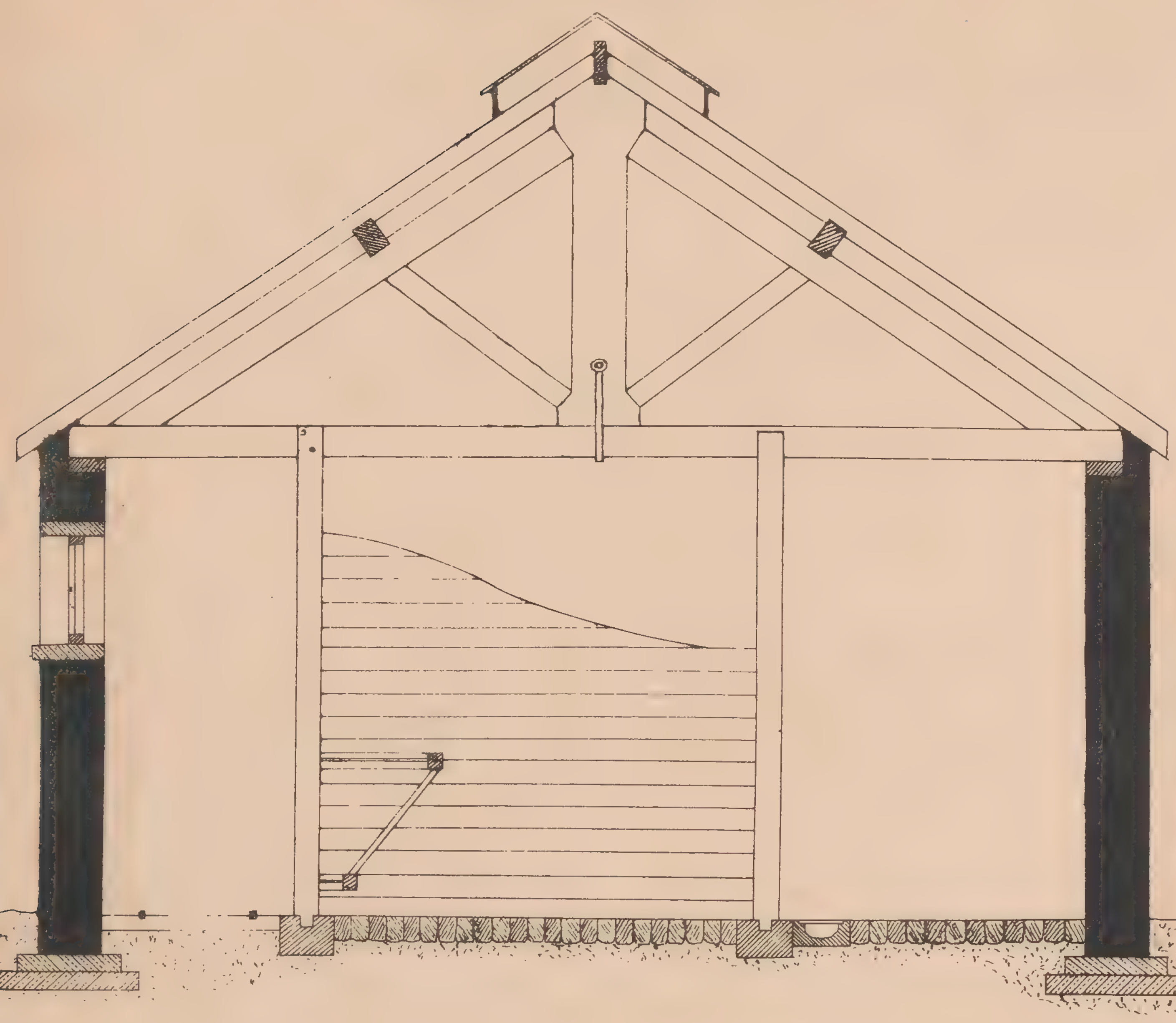

SCULLERY (Bed-Room over).
W. C.
Screen.
KITCHEN (Bed-Room over).
DINING ROOM. (Bed-Room over).
W. C.
HATS (Bed-Room over).
Folding Doors.
MORNING OR BREAKFAST ROOM (Bed-Room over).
DRAWING ROOM (Bed-Room over).
HALL (Dressing-Room over).

GROUND PLAN OF FIG. 7.
SCALE ¼th INCH = 1 FOOT.

DESIGNS OF COACH-HOUSES, STABLES, AND COW-HOUSES.

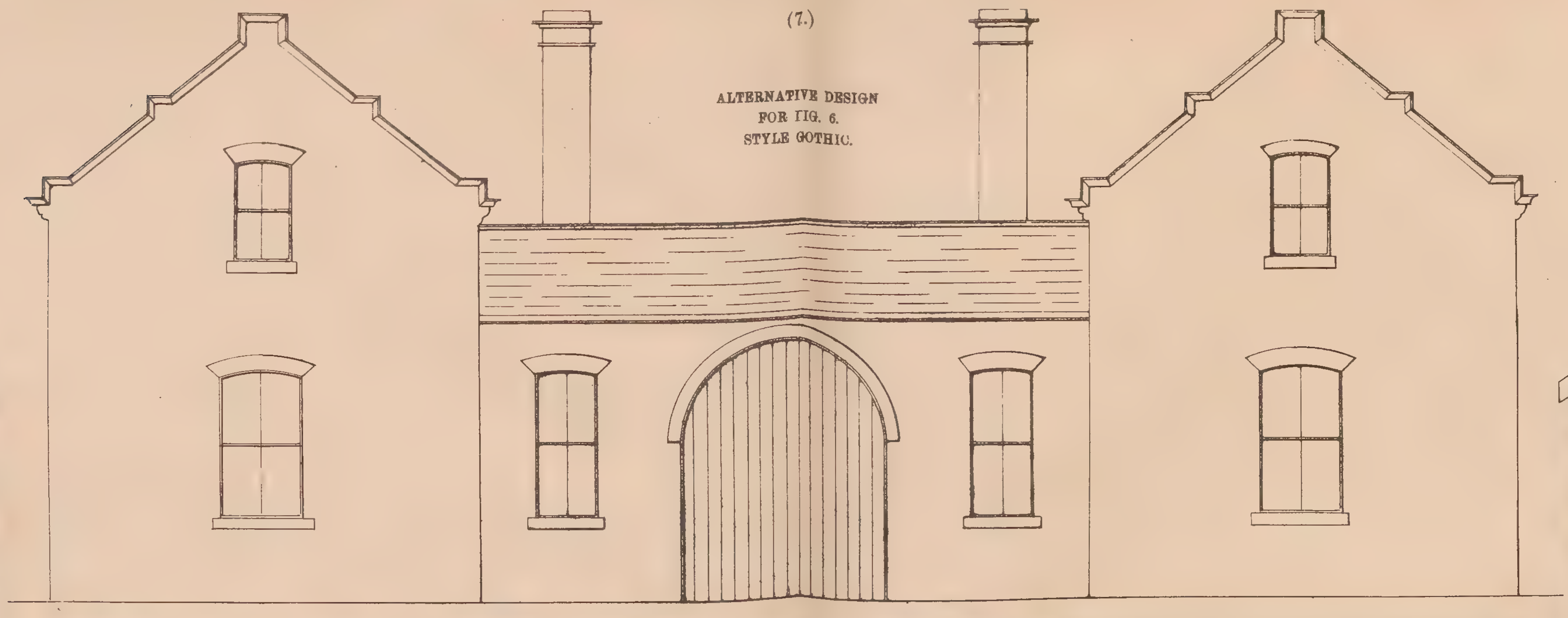
(1)

TRANSVERSE SECTION OF STABLE IN FIG. 2.



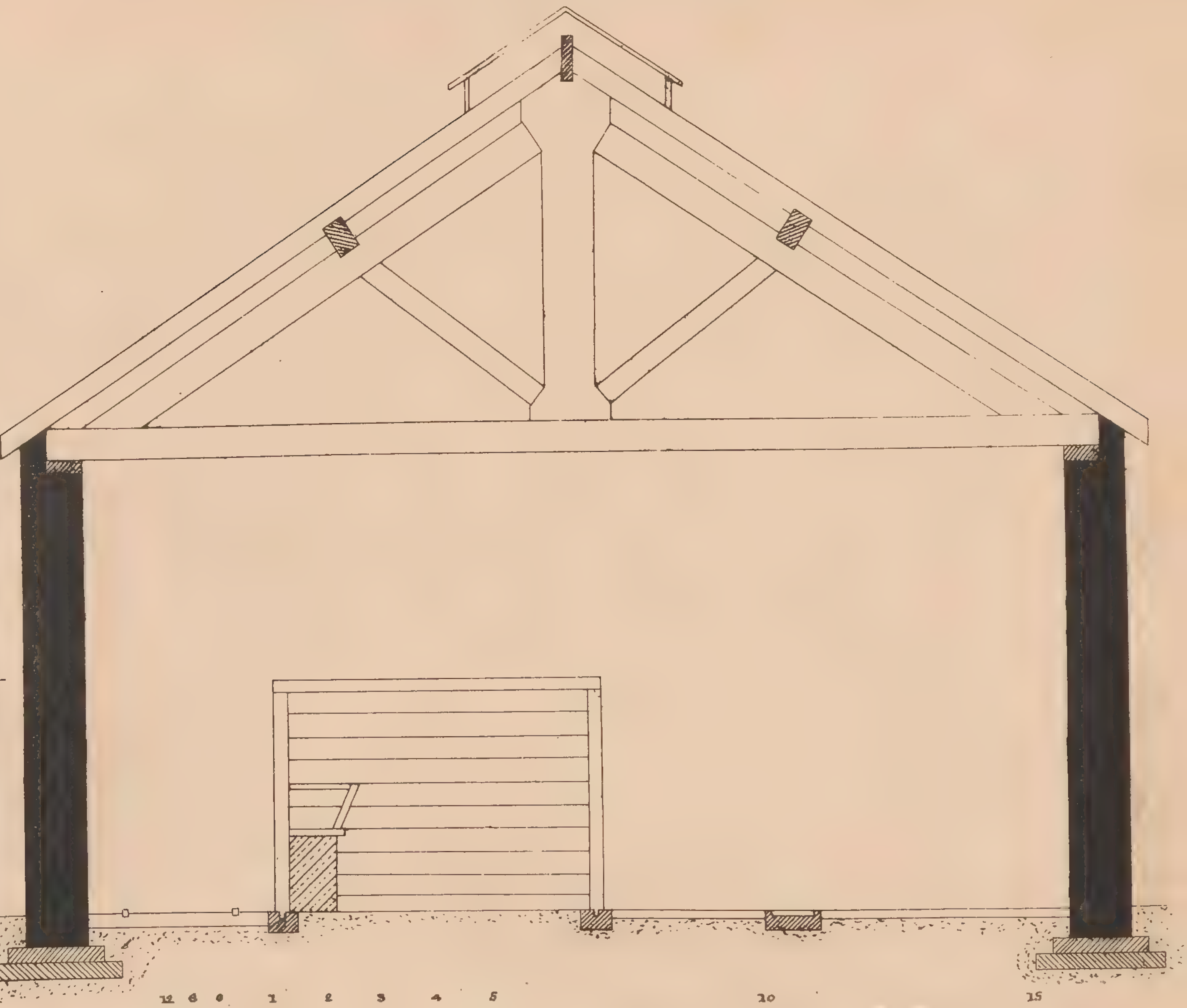
(7.)

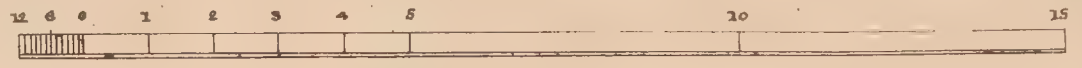
ALTERNATIVE DESIGN
FOR FIG. 6.
STYLE GOTHIC.



(3.)

TRANSVERSE SECTION OF COW-HOUSE IN FIG. 4.

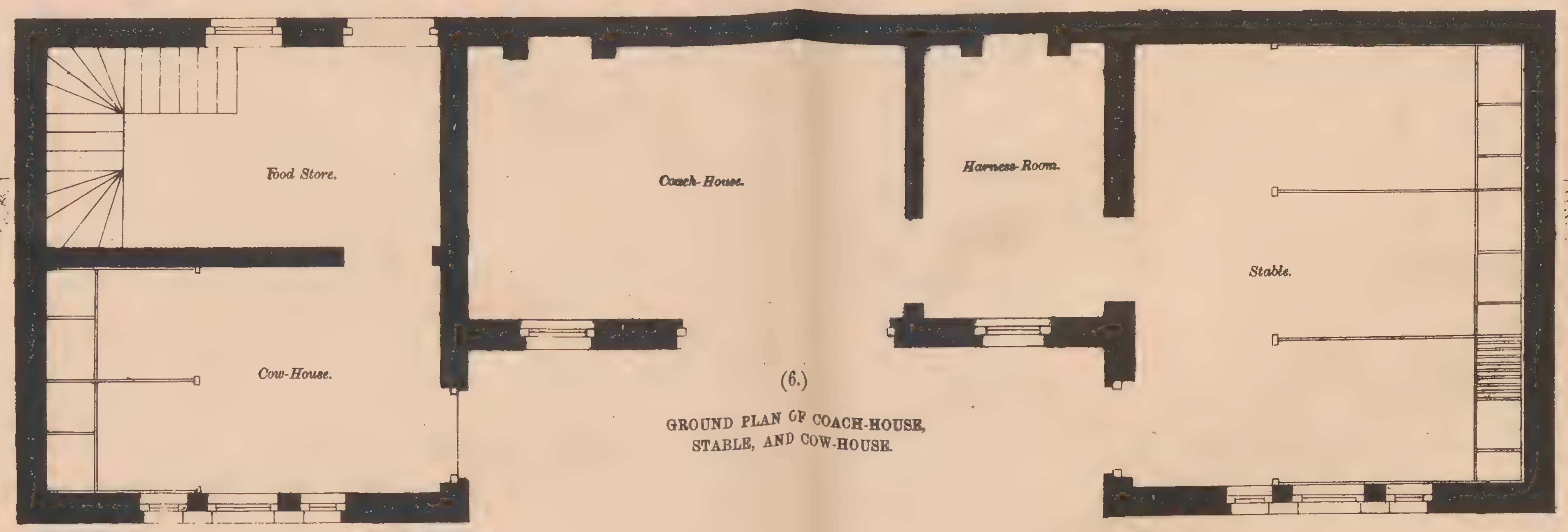



12 6 0 1 2 3 4 5 10 15

SCALE FOR FIGS. 1, 2, 3, 4.

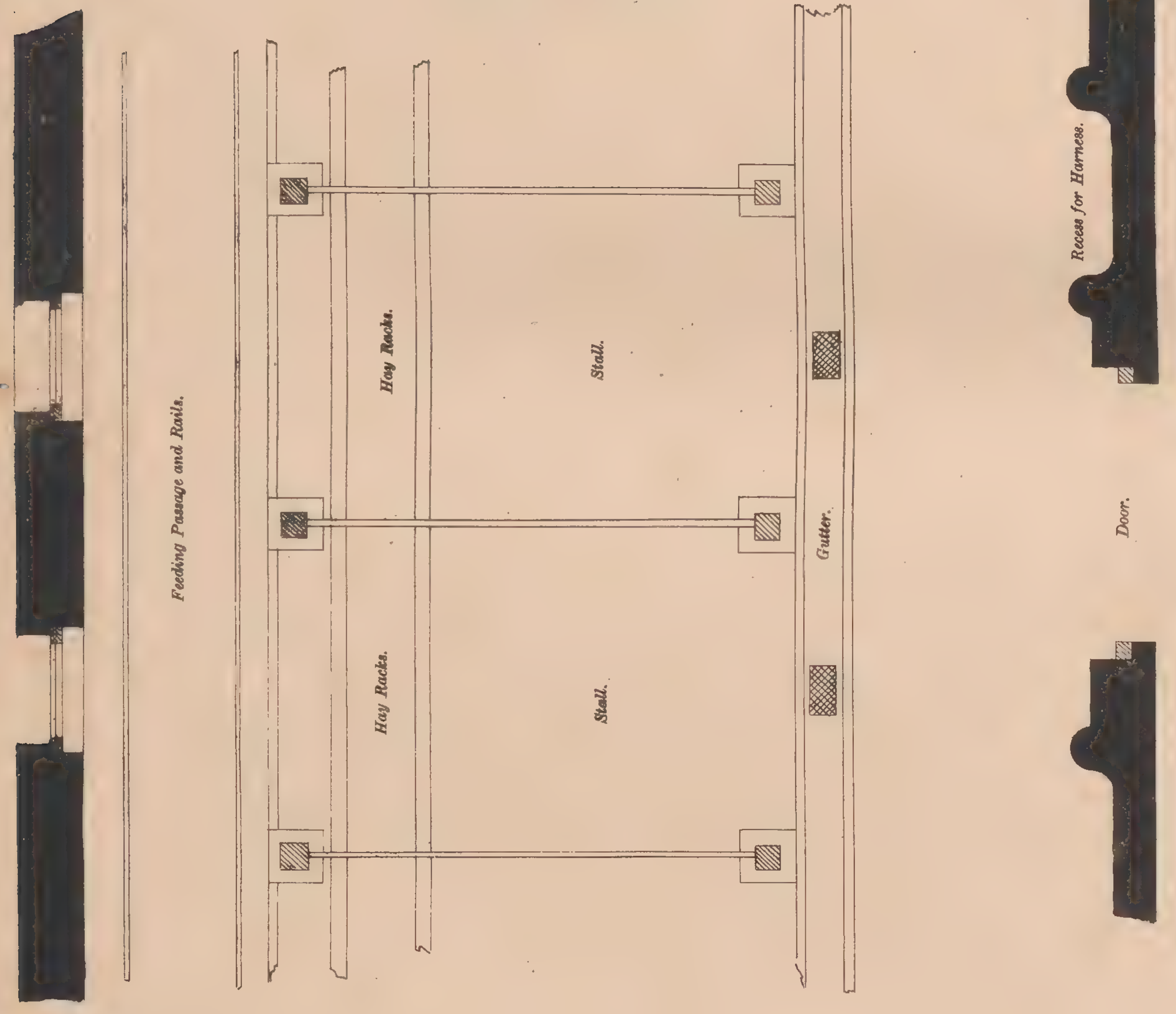
(6.)

GROUND PLAN OF COACH-HOUSE, STABLE, AND COW-HOUSE.


Food Store.
Coach-House.
Harness-Room.
Stable.
Cow-House.

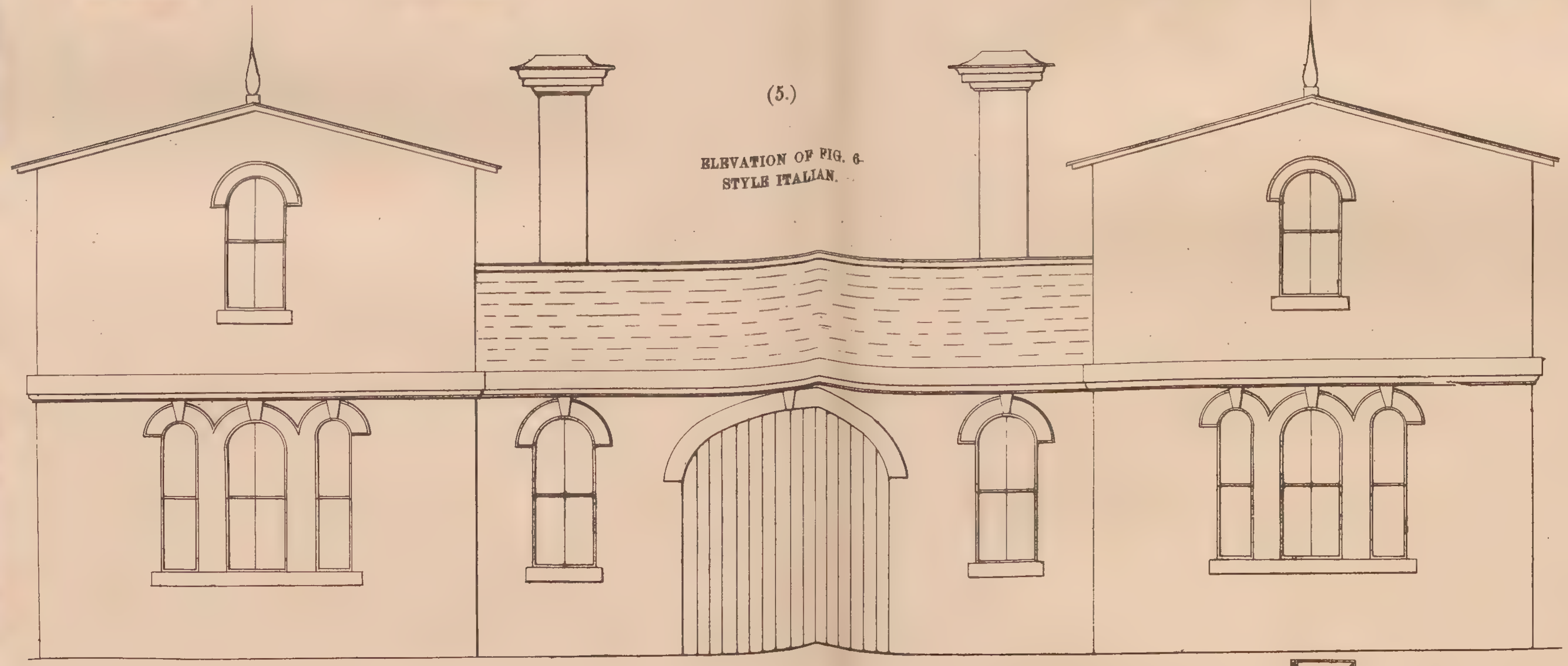
(2.)

GROUND PLAN OF STABLE.


Feeding Passage and Rails.
Hay Racks.
Hay Racks.
Stall.
Stall.
Gutter.
Recess for Harness.
Door.

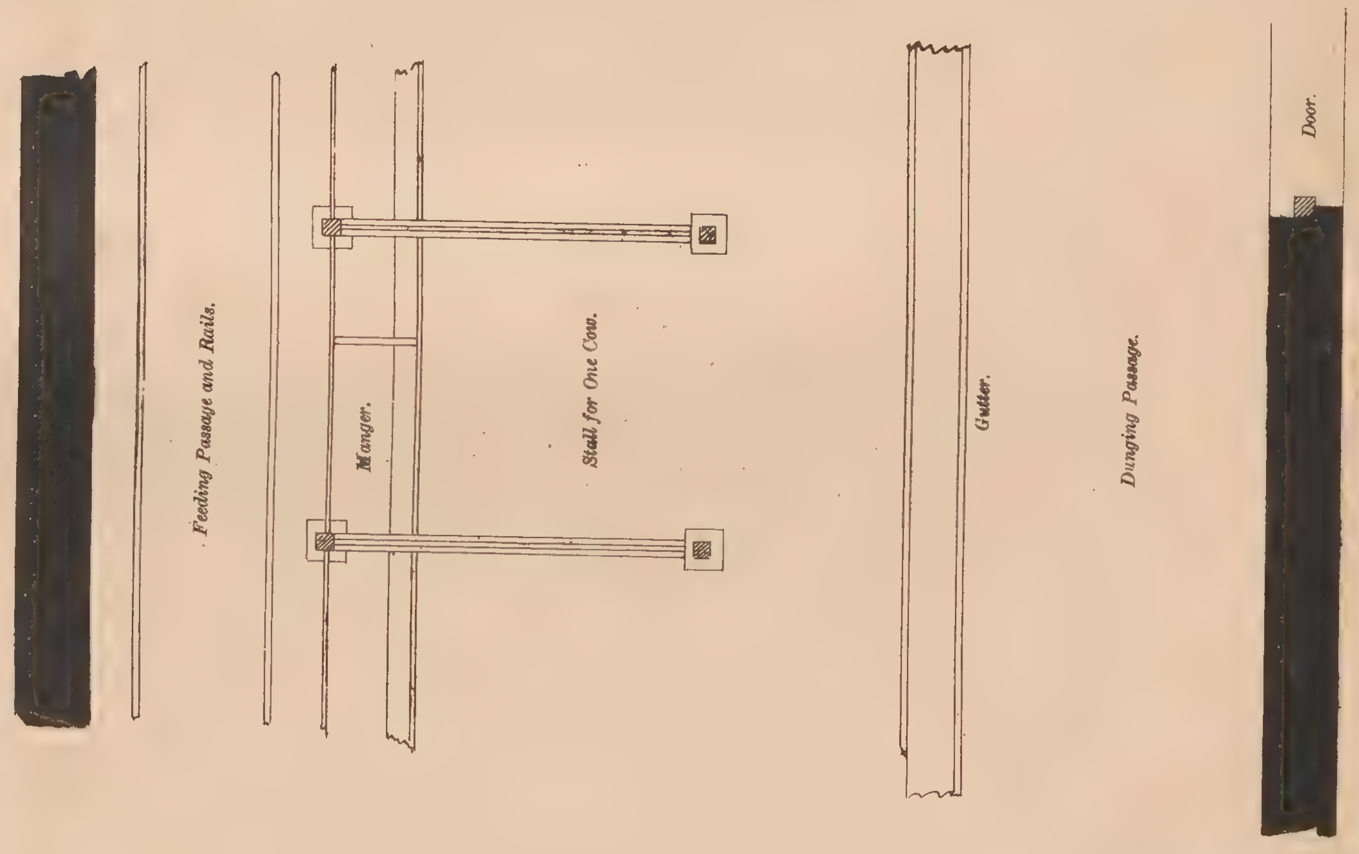
(5.)

ELEVATION OF FIG. 6.
STYLE ITALIAN.



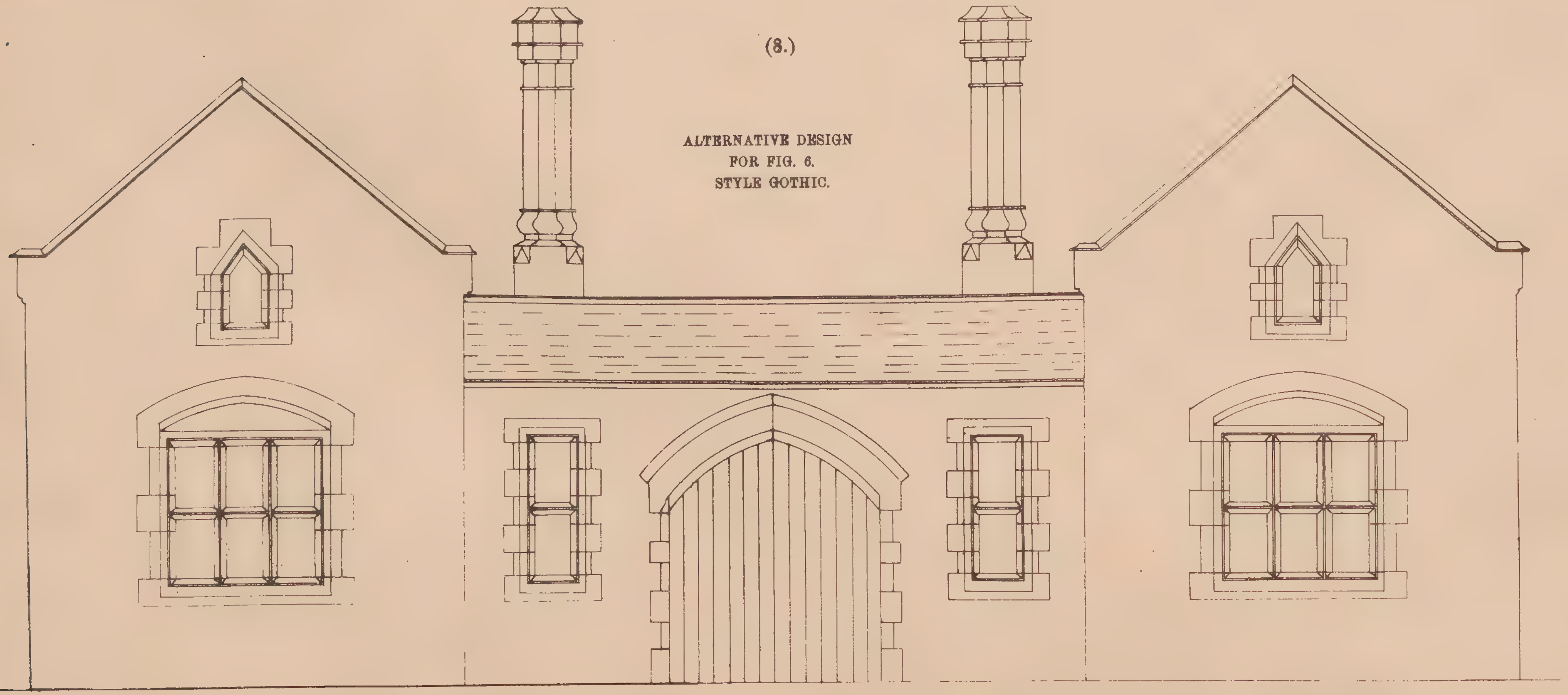
(4.)

GROUND PLAN OF COW-HOUSE.


Feeding Passage and Rails.
Manger.
Stall for One Cow.
Gutter.
Dunging Passage.
Door.

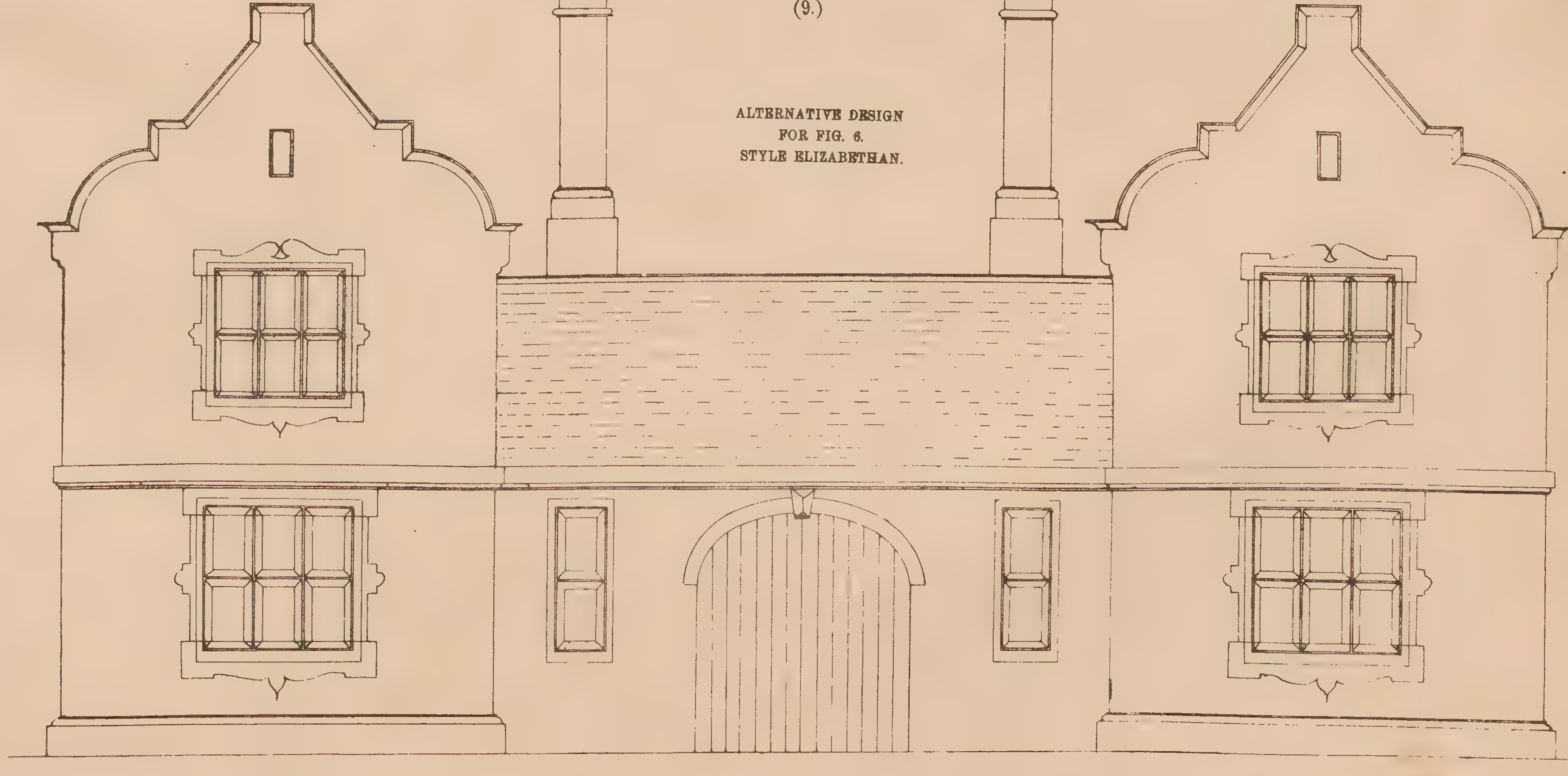
(8.)

ALTERNATIVE DESIGN
FOR FIG. 6.
STYLE GOTHIC.

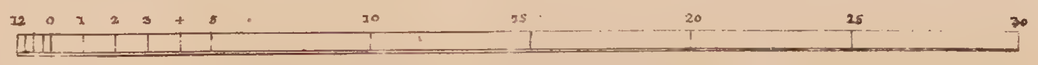


(9.)

ALTERNATIVE DESIGN
FOR FIG. 6.
STYLE ELIZABETHAN.



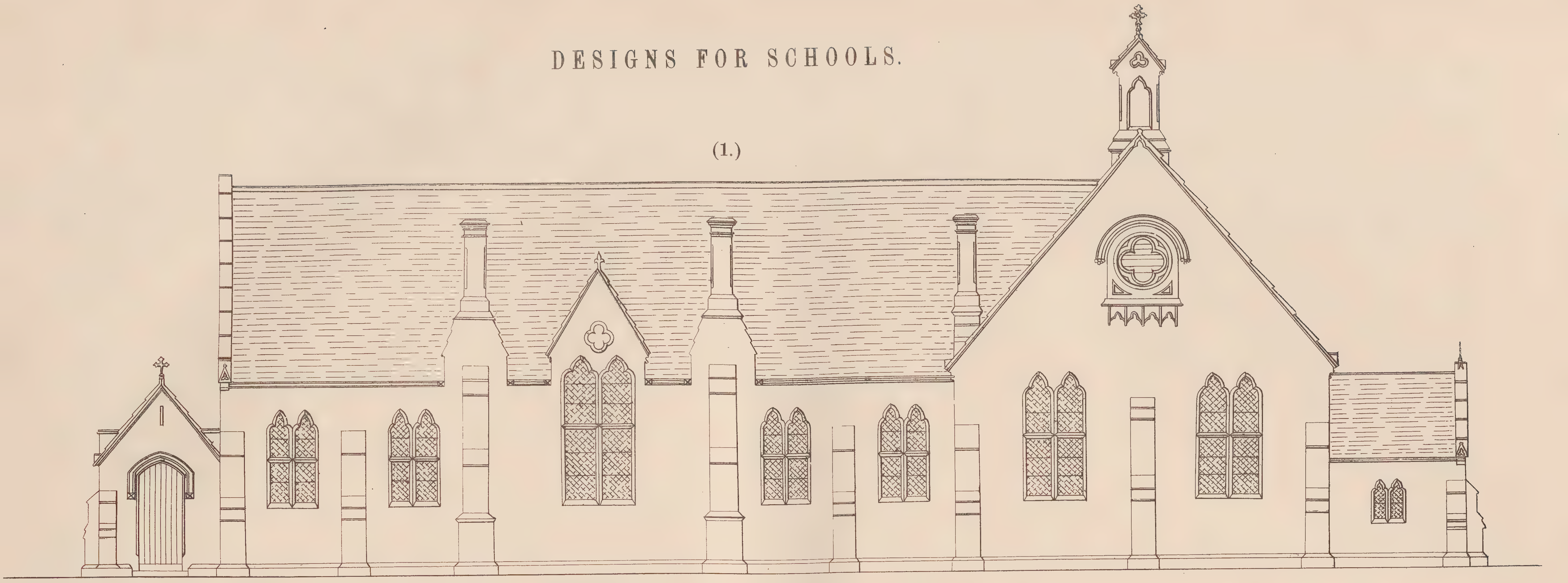
A. FULLARTON & CO., EDINBURGH AND LONDON.


12 0 1 2 3 4 5 10 15 20 25 30

SCALE FOR FIGS. 5, 6, 7, 8 AND 9

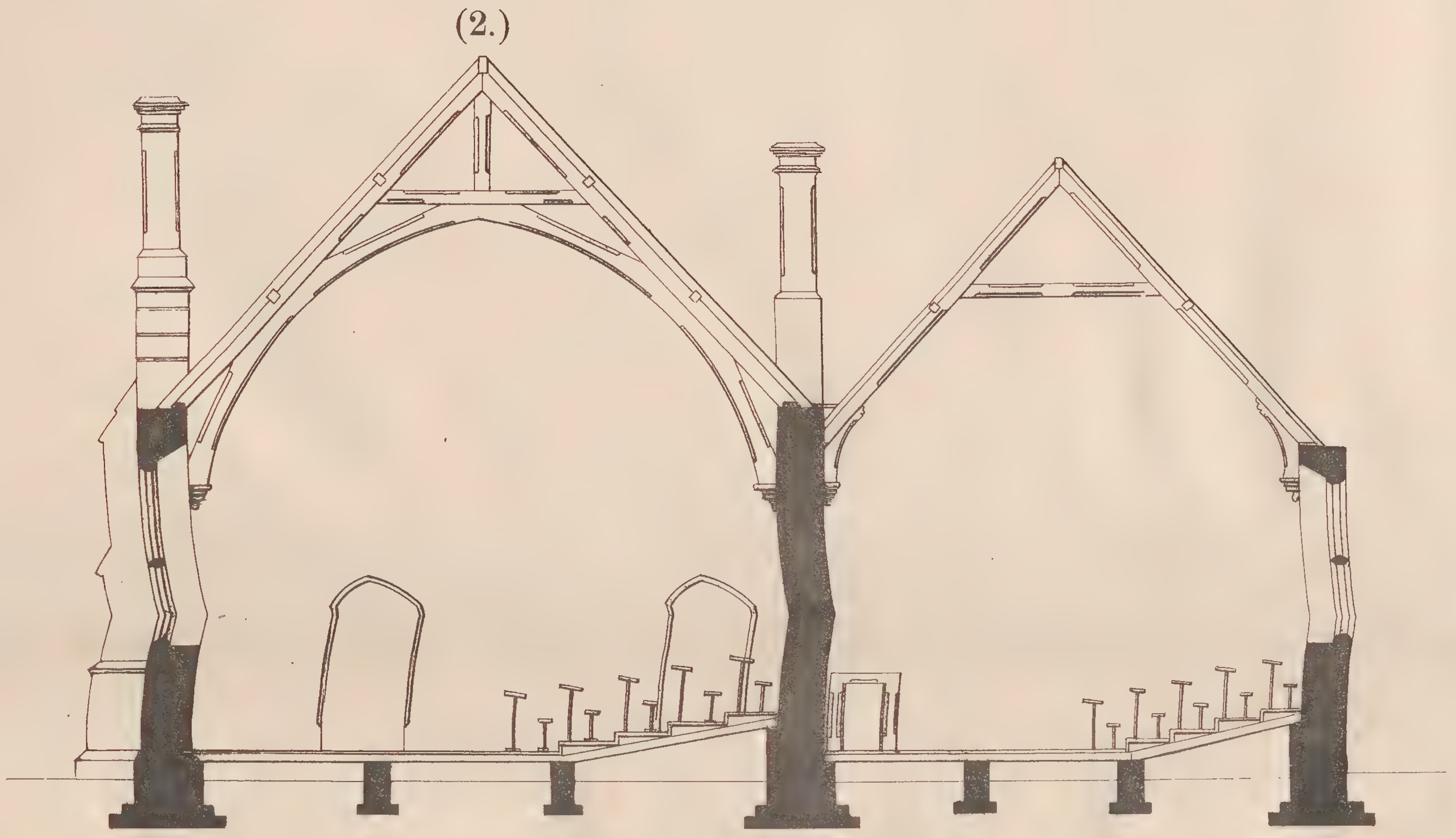
DESIGNS FOR SCHOOLS.

(1.)

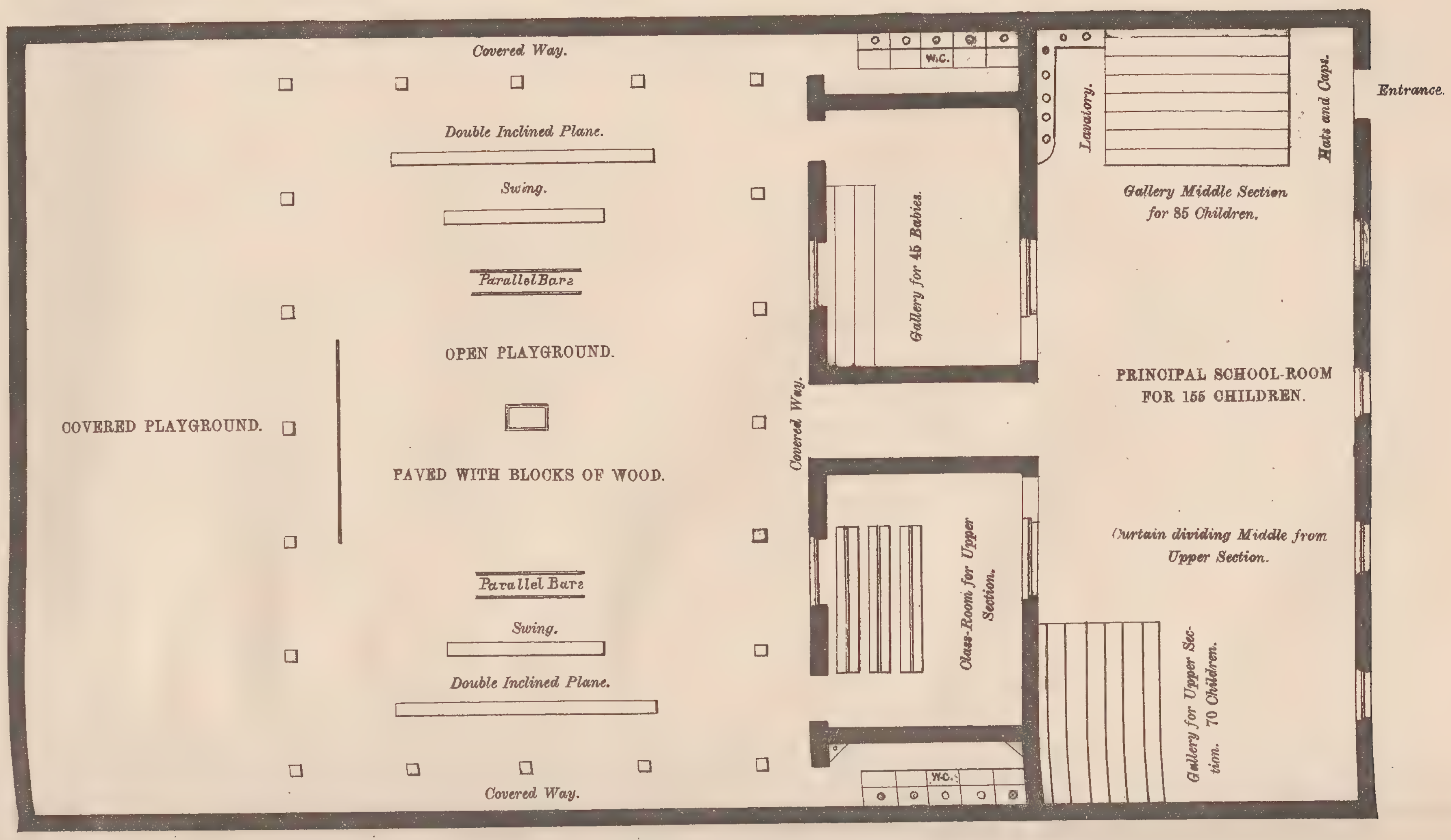


FRONT ELEVATION.

(2.)

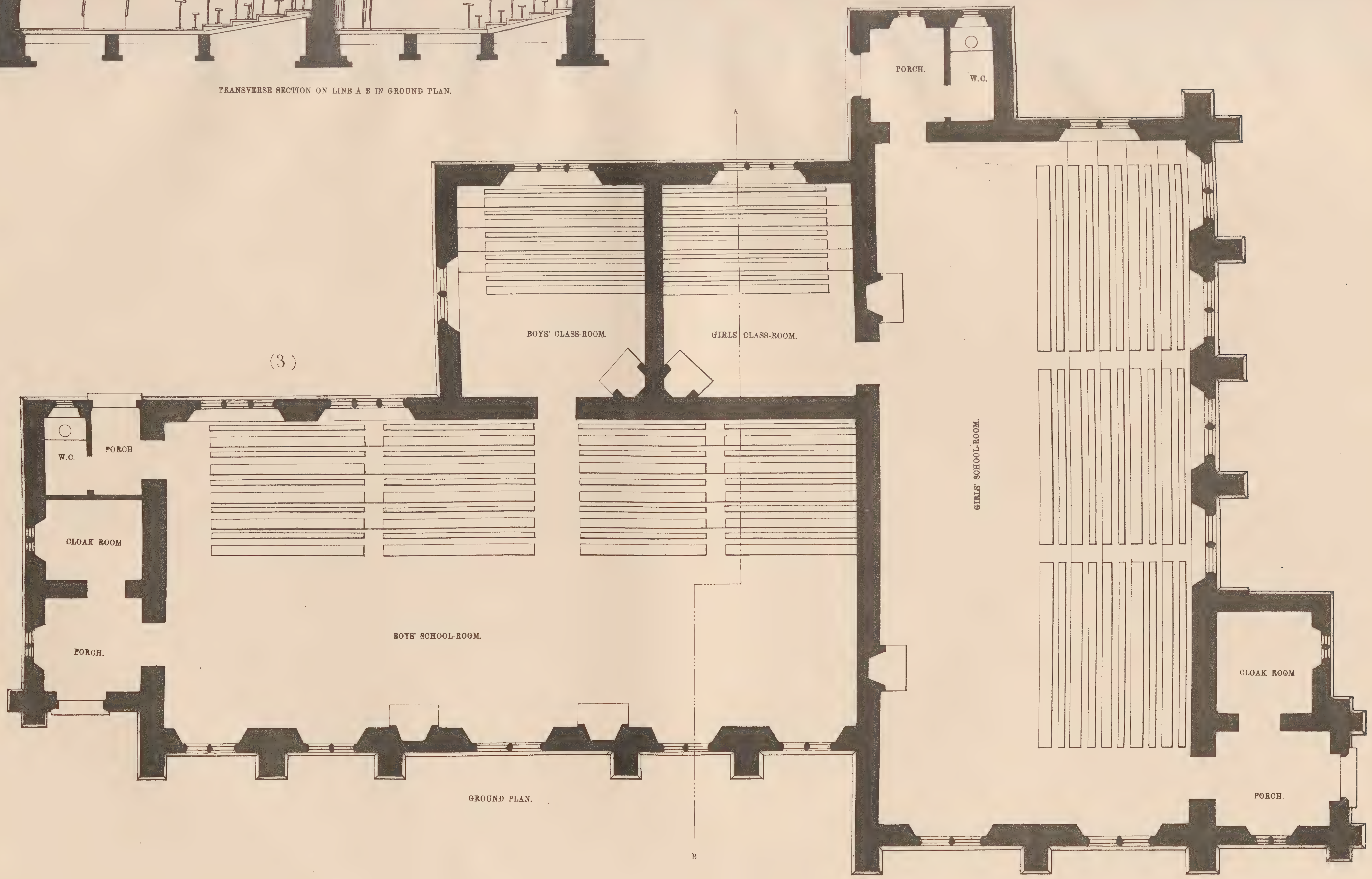


TRANSVERSE SECTION ON LINE A B IN GROUND PLAN.


Covered Way.
Entrance.
Hats and Caps.
Lavatory.
W.C.
Double Inclined Plane.
Swing.
Parallel Bars
Gallery for 45 Babies.
Gallery Middle Section for 85 Children.
OPEN PLAYGROUND.
COVERED PLAYGROUND.
Covered Way.
PRINCIPAL SCHOOL-ROOM FOR 155 CHILDREN.
PAVED WITH BLOCKS OF WOOD.
Curtain dividing Middle from Upper Section.
Class-Room for Upper Section.
Parallel Bars
Swing.
Double Inclined Plane.
Gallery for Upper Section. 70 Children.
W.C.
Covered Way.

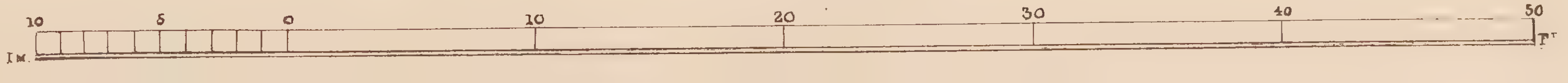
MODEL PLAN FOR INFANT SCHOOL BUILDINGS BY THE HOME AND COLONIAL SCHOOL SOCIETY.
Scale 1 inch = 12 feet.

(3)


PORCH.
W.C.
A
BOYS' CLASS-ROOM.
GIRLS' CLASS-ROOM.
W.C.
PORCH
CLOAK ROOM
GIRLS' SCHOOL-ROOM.
BOYS' SCHOOL-ROOM.
PORCH.
CLOAK ROOM
PORCH.
B

GROUND PLAN.

SCALE FOR FIGS. 1, 2, 3.

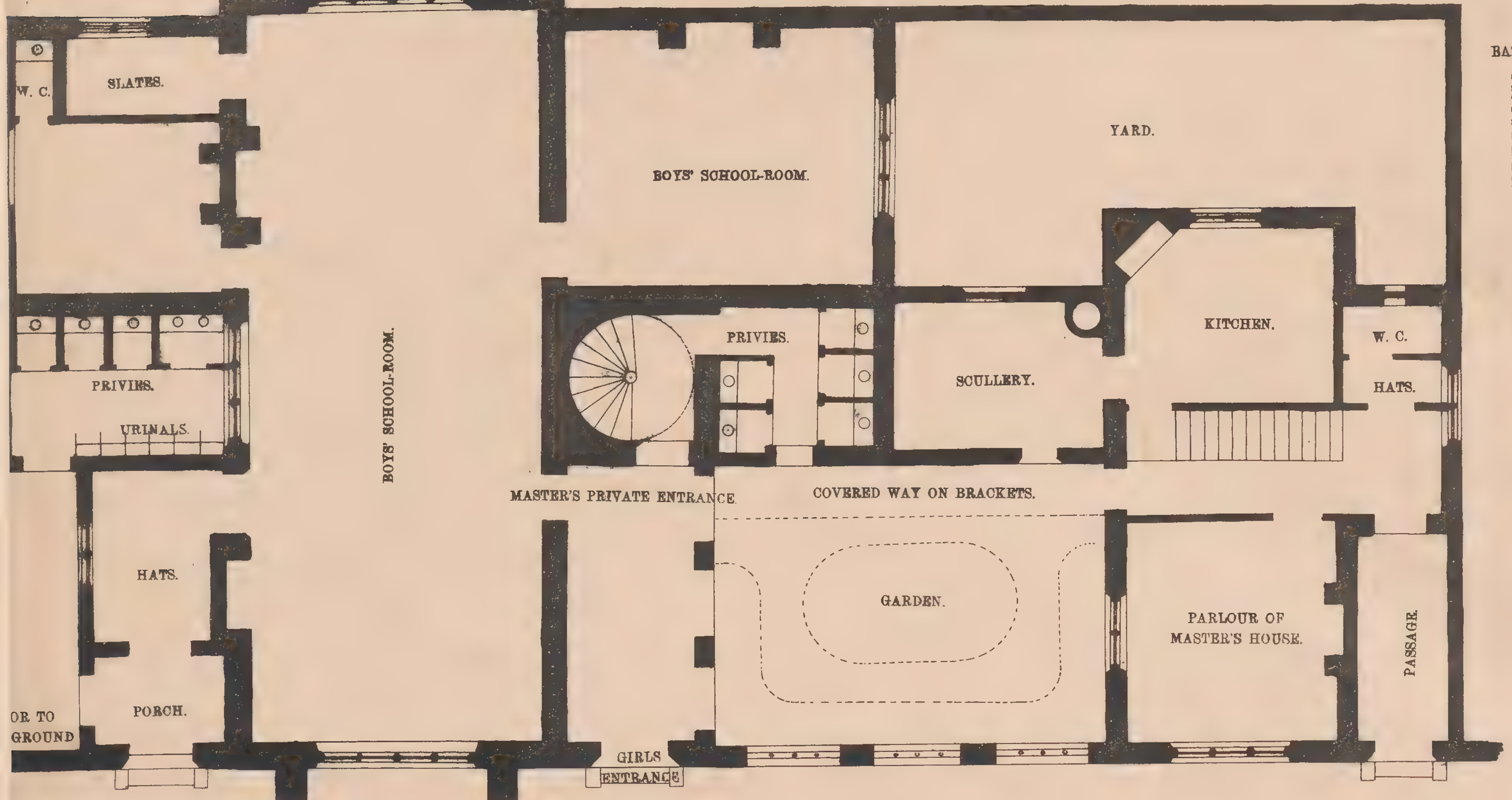

10
5
0
10
20
30
40
50
I M.
F T.

PLANS OF SCHOOLS.—TRAINING SCHOOLS AND REFORMATORY.

PLATE XXX.

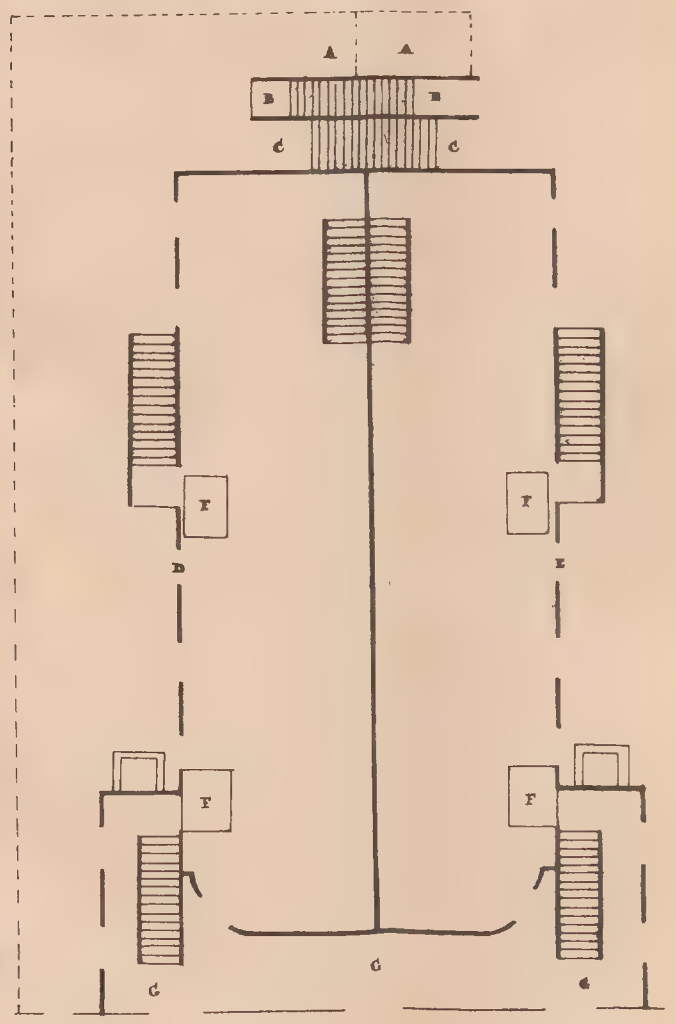
(1.)

GROUND PLAN OF BOYS AND GIRLS' SCHOOL.
Scale one-eighth Inch = 1 Foot.


W. C.
SLATES.
BOYS' SCHOOL-ROOM.
YARD.
PRIVIES.
URINALS.
BOYS' SCHOOL-ROOM.
PRIVIES.
SCULLERY.
KITCHEN.
W. C.
HATS.
MASTER'S PRIVATE ENTRANCE
COVERED WAY ON BRACKETS.
HATS.
GARDEN.
PARLOUR OF MASTER'S HOUSE.
PASSAGE.
OR TO GROUND
PORCH.
GIRLS ENTRANCE

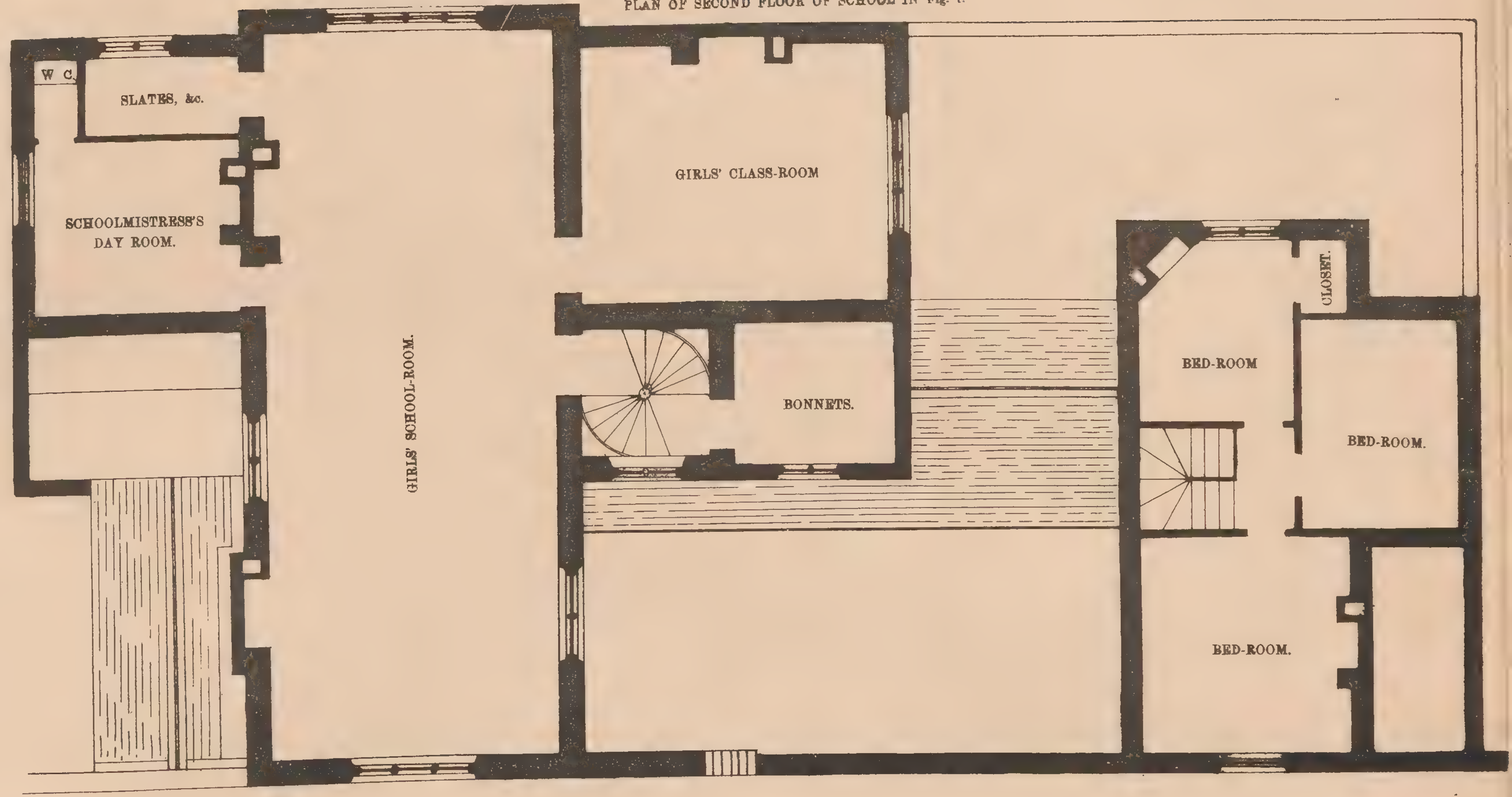
(10.)

BASEMENT PLAN OF PRIMARY SCHOOL, NEW YORK.



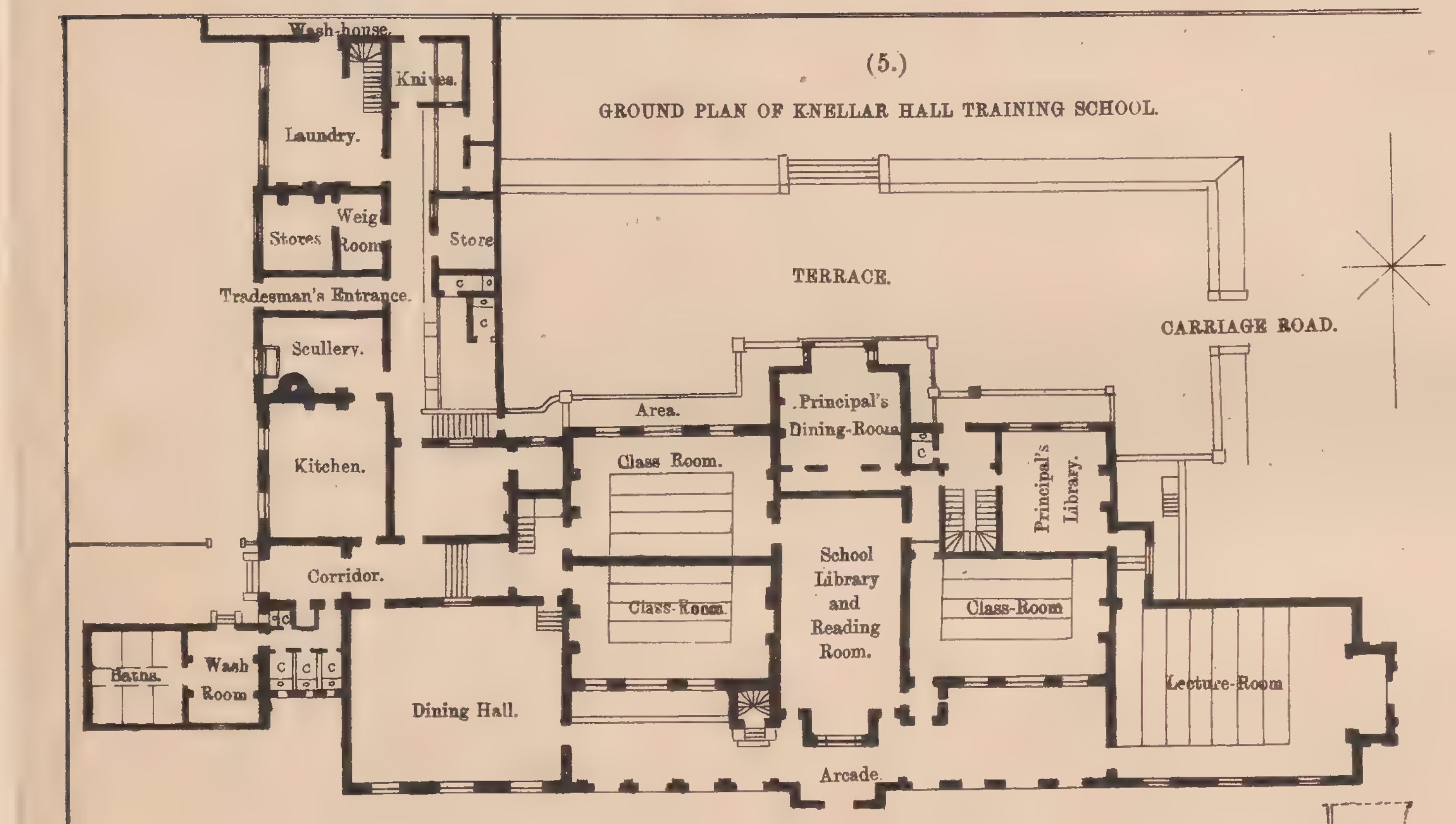
(2.)

PLAN OF SECOND FLOOR OF SCHOOL IN Fig. 1.


W. C.
SLATES, &c.
SCHOOLMISTRESS'S DAY ROOM.
GIRLS' CLASS-ROOM
GIRLS' SCHOOL-ROOM.
BONNETS.
CLOSET.
BED-ROOM.
BED-ROOM.
BED-ROOM.

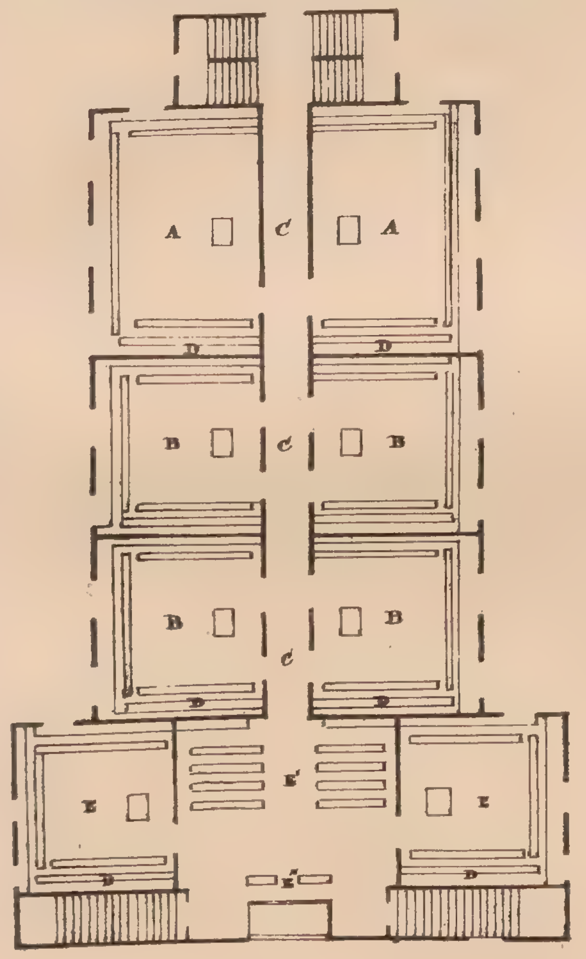
(5.)

GROUND PLAN OF KNELLAR HALL TRAINING SCHOOL.


Wash-house.
Knives.
Laundry.
Stores
Weig Room
Store
Tradesman's Entrance.
TERRACE.
CARRIAGE ROAD.
Scullery.
Area.
Principal's Dining-Room
Kitchen.
Class Room.
Principal's Library.
Corridor.
School Library and Reading Room.
Class-Room
Class-Room
Baths.
Wash Room
Dining Hall.
Lecture-Room
Arcade.

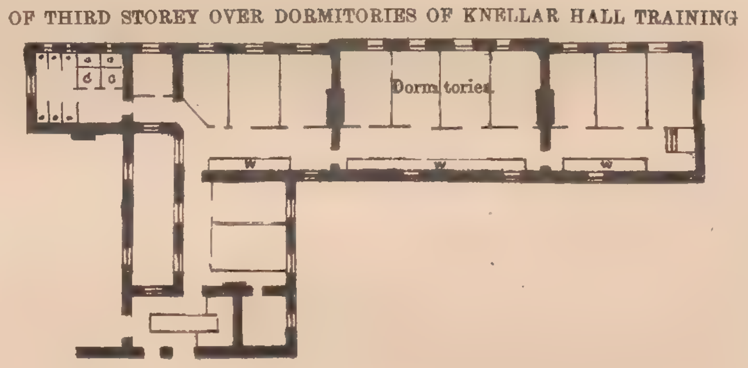
(11.)

PLAN OF SECOND FLOOR OF PRIMARY SCHOOL IN Fig. 10.


A
C
A
D
D
B
C
B
B
B
C
E
E
E

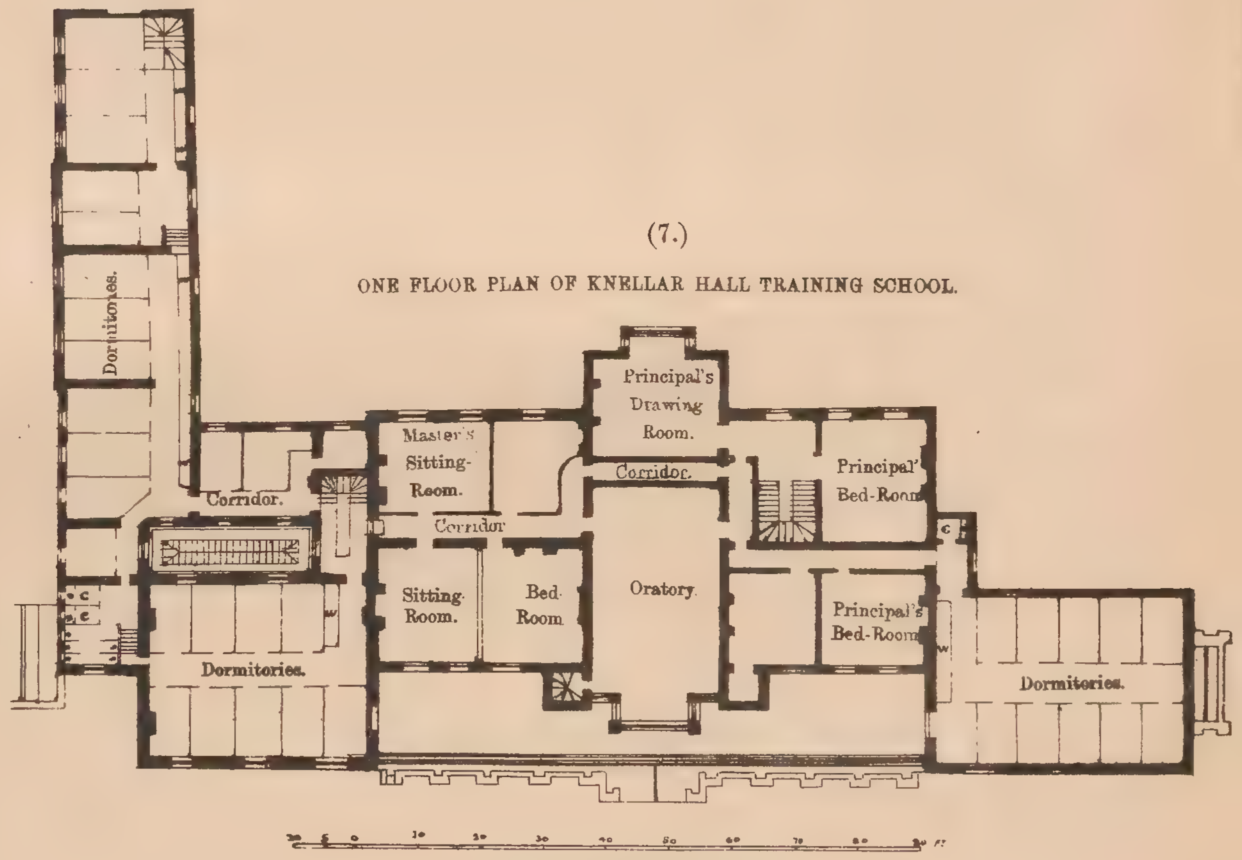
(9.)

PLAN OF THIRD STOREY OVER DORMITORIES OF KNELLAR HALL TRAINING SCHOOL.

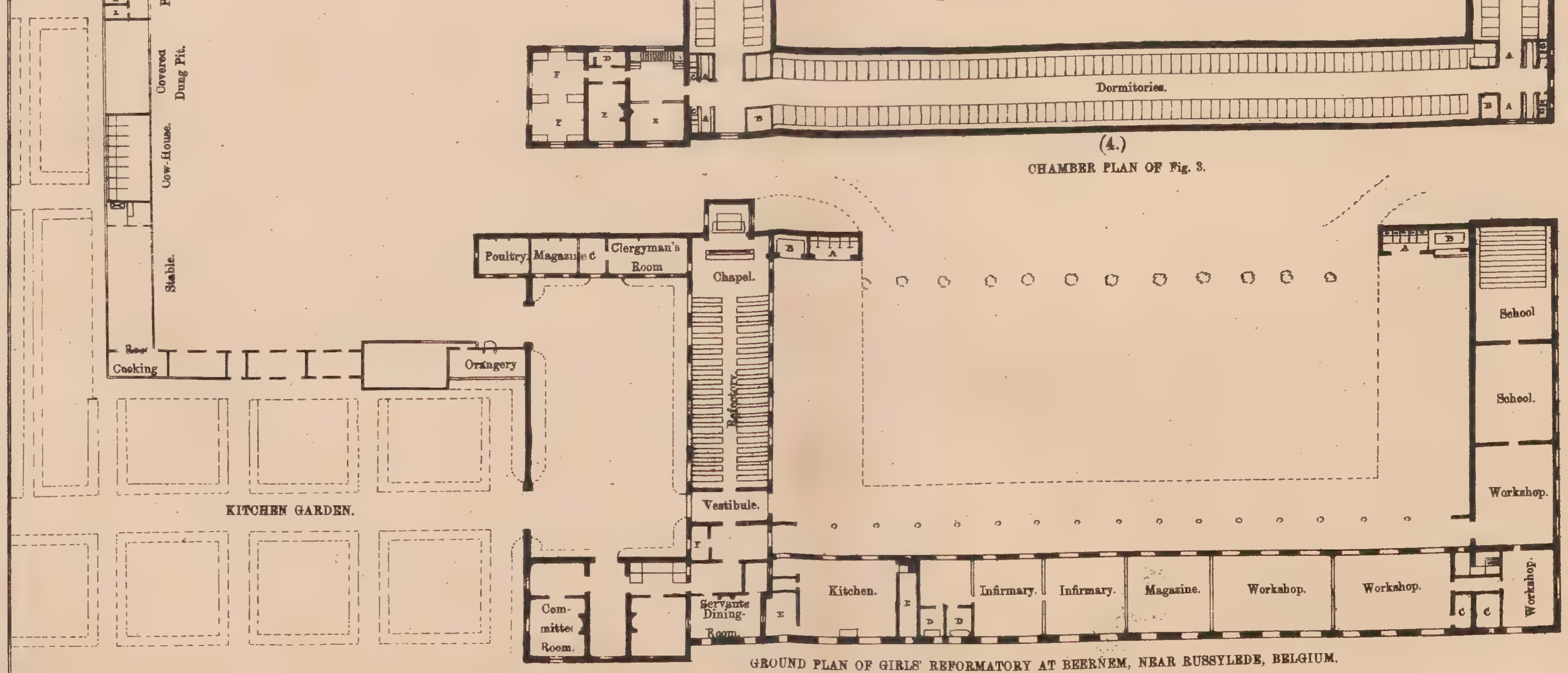

Dormitories.

(7.)

ONE FLOOR PLAN OF KNELLAR HALL TRAINING SCHOOL.


Dormitories.
Principal's Drawing Room.
Master's Sitting-Room.
Corridor.
Principal' Bed-Room
Corridor.
Corridor
Sitting-Room.
Bed Room
Oratory.
Principal's Bed-Room
Dormitories.
Dormitories.
0
10
20
30
40
50
60
70
80
90 FT

SCALE FOR Figs. 5, 6, 7, 8, 9.

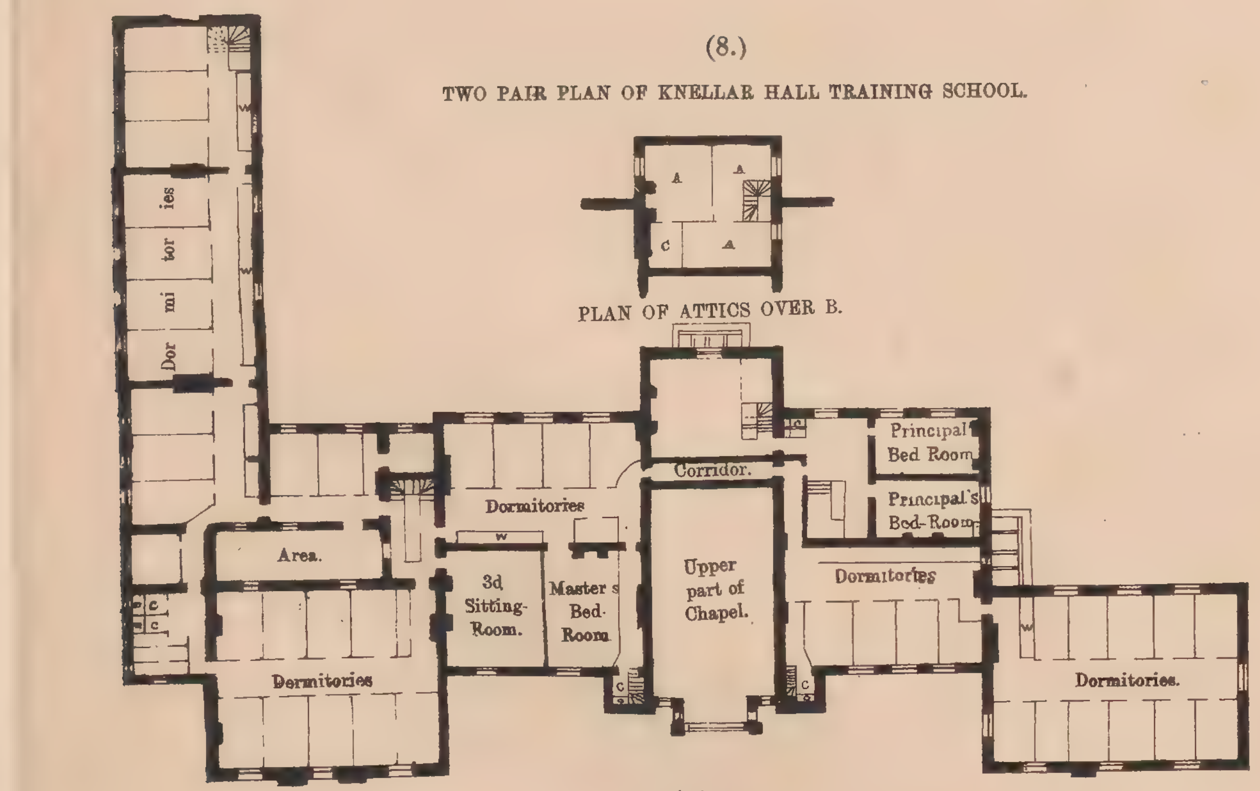

Dormitories.
Dormitories.
Dormitories.
A
B
E
F

(4.)

CHAMBER PLAN OF Fig. 3.

(8.)

TWO PAIR PLAN OF KNELLAR HALL TRAINING SCHOOL.

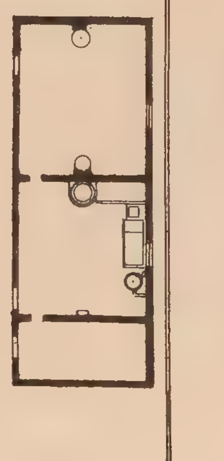

A
A
C
A
Dormitories
Corridor.
Principal Bed Room
Principal's Bed-Room
Dormitories
Area.
3d Sitting-Room.
Master's Bed-Room
Upper part of Chapel.
Dormitories
Dormitories
Dormitories.

PLAN OF ATTICS OVER B.

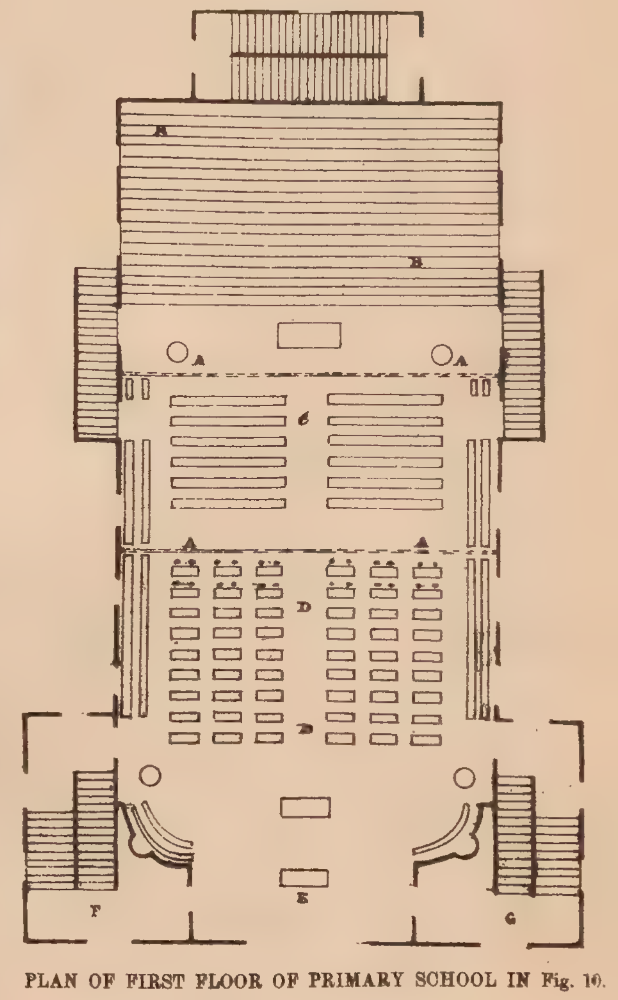
Pigs.
Covered Dung Pit.
Cow-House.
Stable.
Beer Cooking
Orangery
KITCHEN GARDEN.
Poultry.
Magazine
Clergyman's Room
Chapel.
Refectory
Vestibule.
School
School.
Workshop.
Com-mittee Room.
Servants Dining-Room.
Kitchen.
Infirmary.
Infirmary.
Magazine.
Workshop.
Workshop.
Workshop.

GROUND PLAN OF GIRLS' REFORMATORY AT BEERNEM, NEAR RUSSYLEDE, BELGIUM.

(3.)

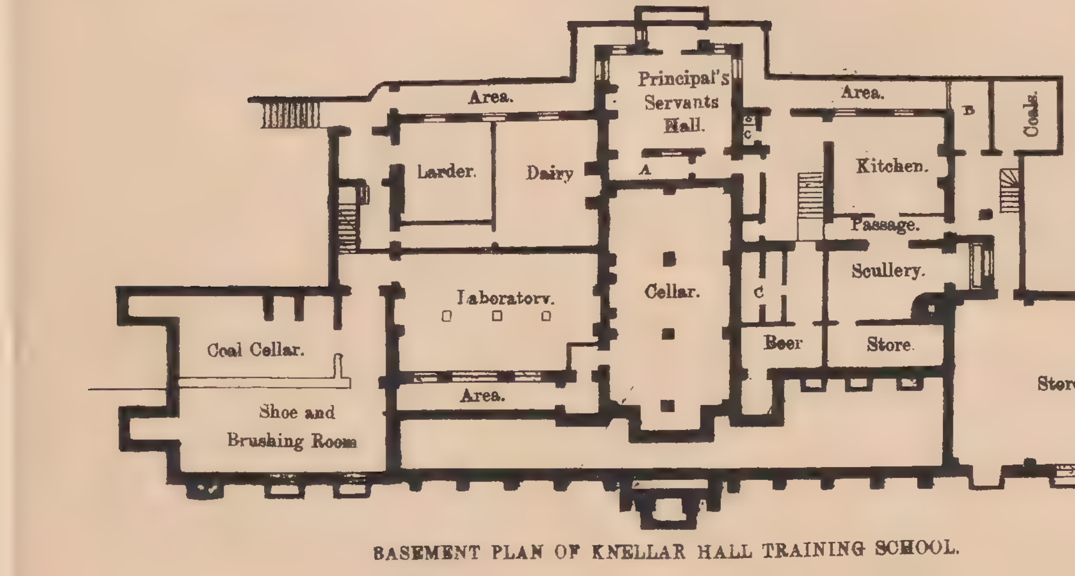


(12.)



PLAN OF FIRST FLOOR OF PRIMARY SCHOOL IN Fig. 10.

(6)

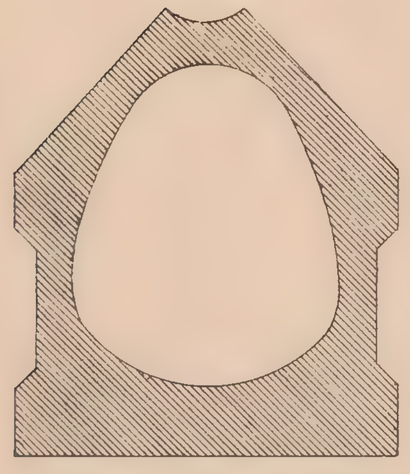

Area.
Principal's Servants Hall.
Area.
B
Coals.
Larder.
Dairy
A
Kitchen.
Passage.
Scullery.
Laboratory.
Cellar.
C
Coal Cellar.
Beer
Store.
Shoe and Brushing Room
Area.
Store Cellar.

BASEMENT PLAN OF KNELLAR HALL TRAINING SCHOOL.

HOLLOW BRICKWORK, DRAINAGE, WATER SUPPLY AND OTHER HOUSE CONVENIENCES.

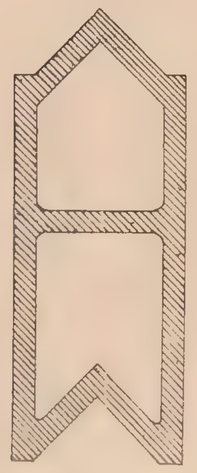
PLATE XXXI.

Fig 1.



Stewart's Hollow Brick.

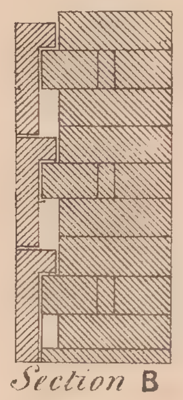
Fig 2.



Hertslett's Hollow Brick.

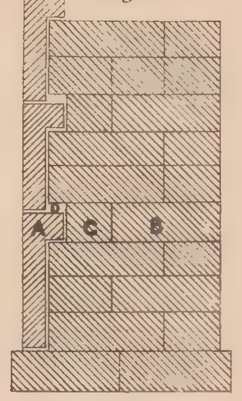
Taylor's Stone Lining for Walls
Figs 3. 4. 5. 6.

Fig 5.



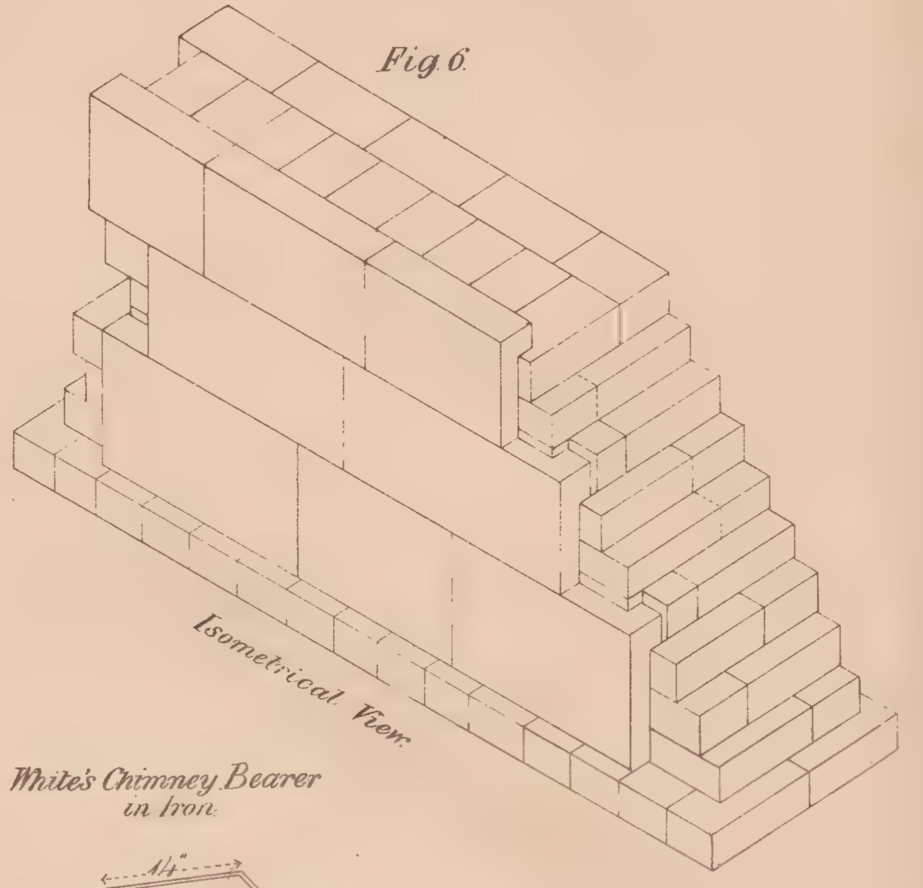
Section B.

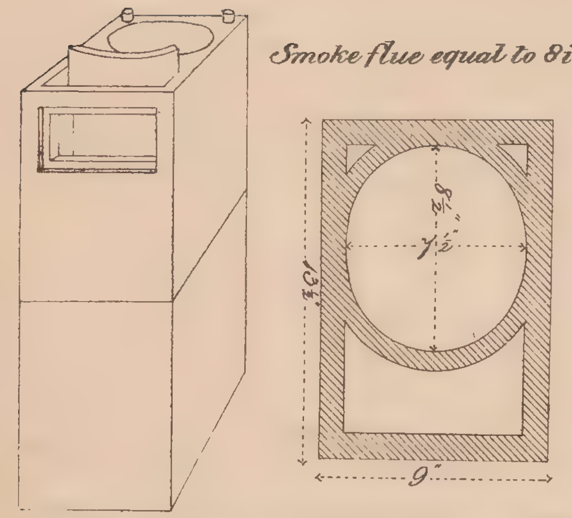
Fig 4.



Section A.

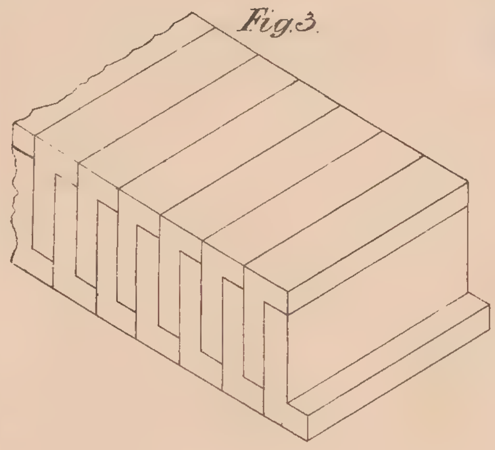
Fig 6.


Isometrical View


Smoke flue equal to 8inch dia.
13½
7½
13½
9

Doulton's Combined Air and Smoke Flue.

Fig 3.



White's Chimney Bearer in iron.

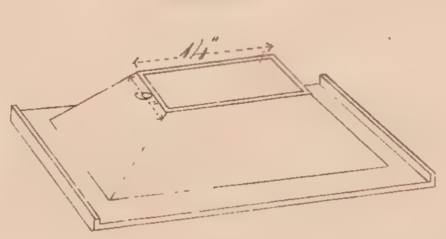
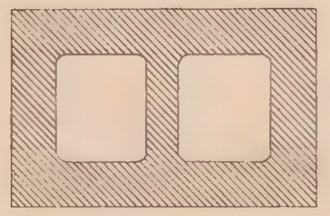


Fig 12.



Hollow Bricks.

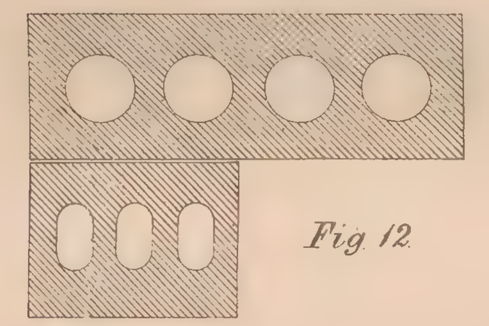


Fig 12.

Section of Ransome's Filter.

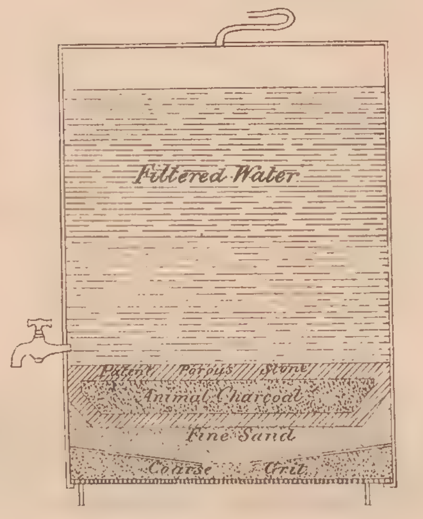
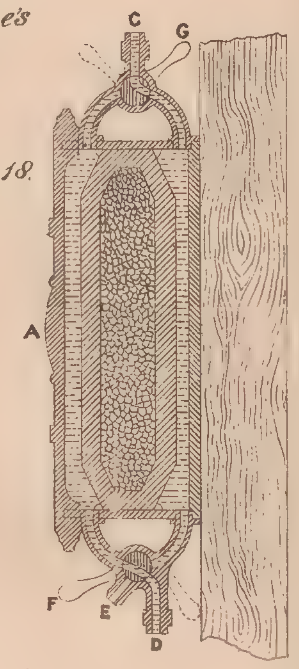
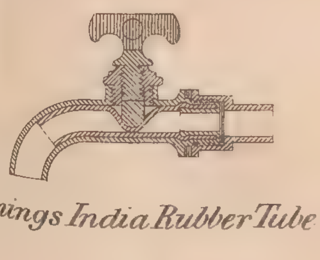
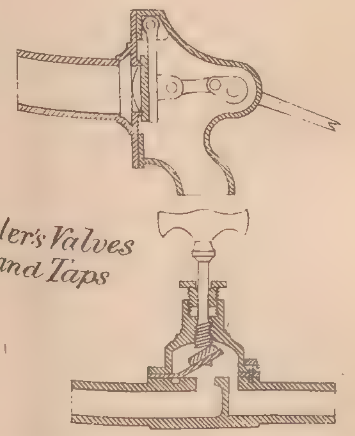

Filtered Water
Animal Charcoal
Fine Sand
Coarse Grit

Fig 18.



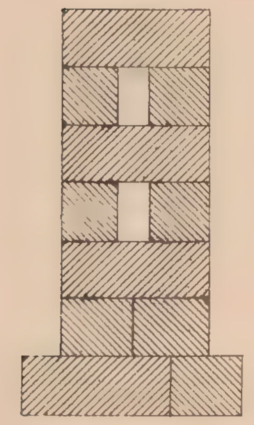


Jennings India Rubber Tube Tap shut.



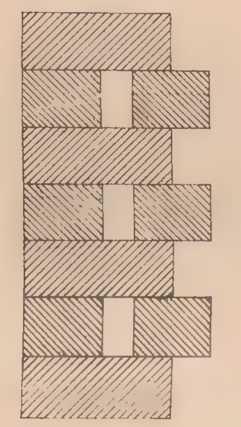
Tyler's Valves and Taps.

Fig 7.



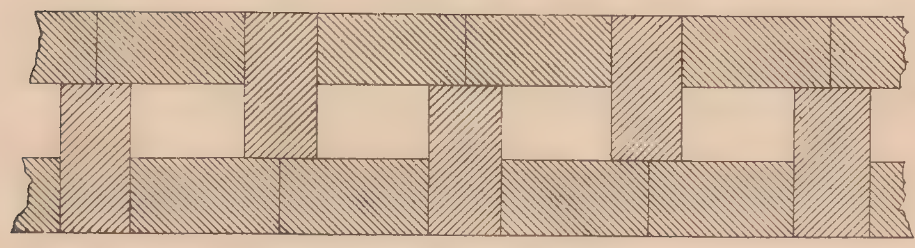
9inch Hollow Wall.

Fig 8.



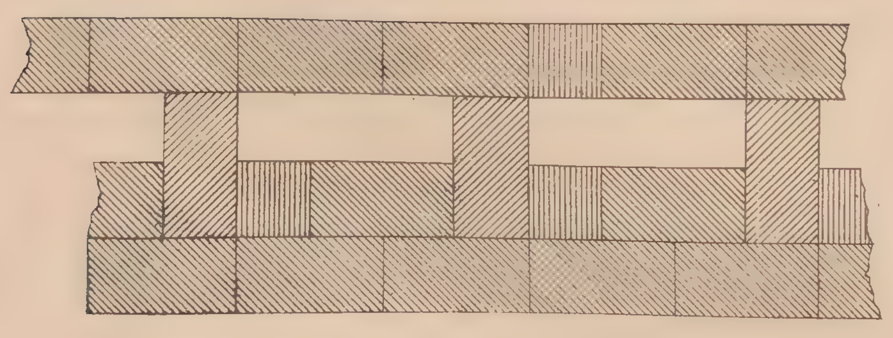
14inch Hollow Wall.

Fig 9.



12 inch Hollow Wall.

Fig. 10.



16inch Hollow Wall.

Fig 11.

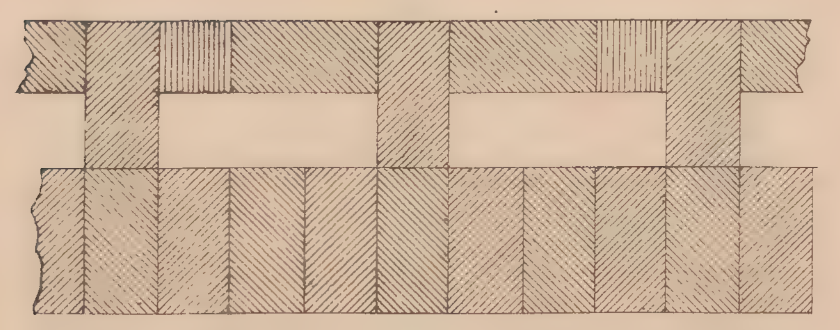
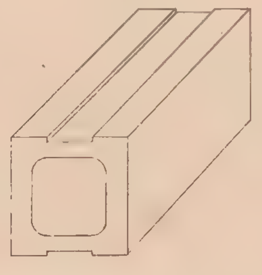
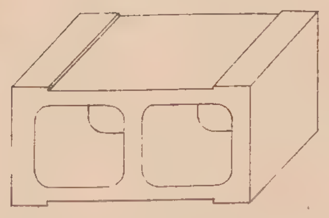


Fig 13.



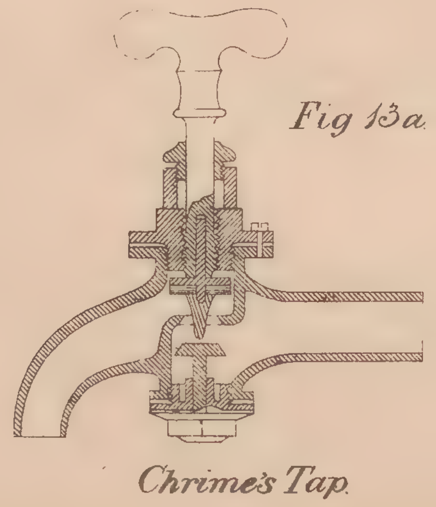
Norton's Stretcher Hollow Brick.

Fig 14.



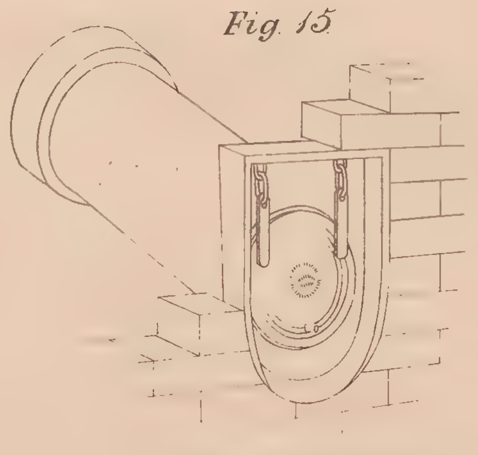
Norton's Header Hollow Brick.

Fig 13a.

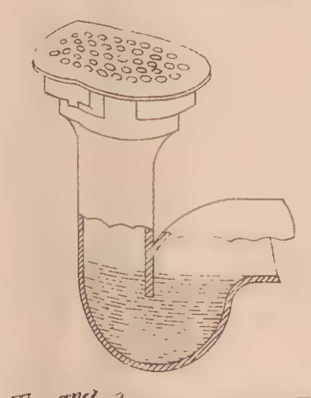


Chrime's Tap.

Fig 15.



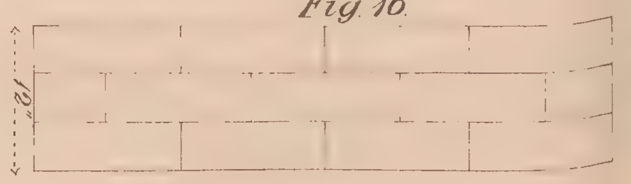
Stone Drain Flap.



Tye and Andrew's Sink Trap.

Roberts's Hollow Bricks.

Fig 16.



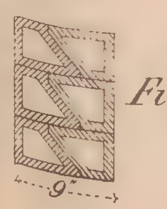


Fig 16a.

French Solid Cement Blocks for Hollow Walls.
Figs 17. 18. 19.

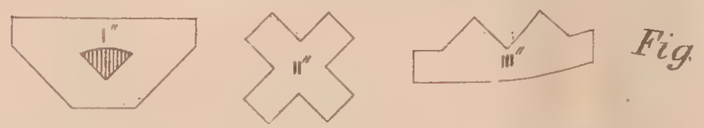


Fig 18.

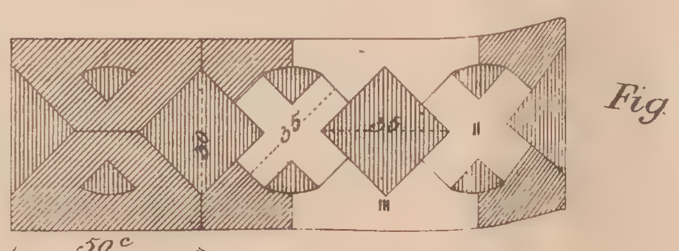


Fig 17.

Fig 19.

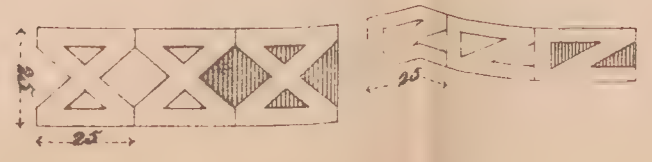


Fig 21.

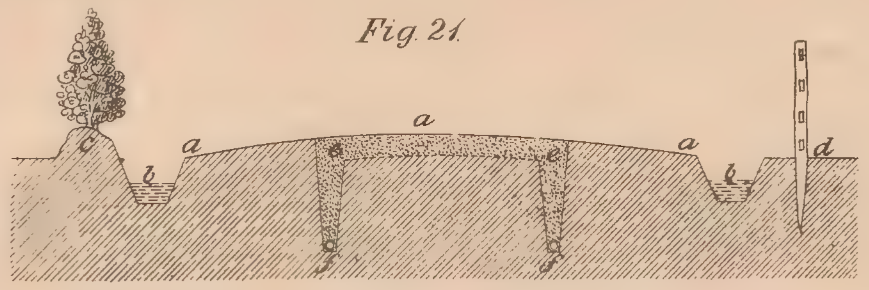


Fig 22.

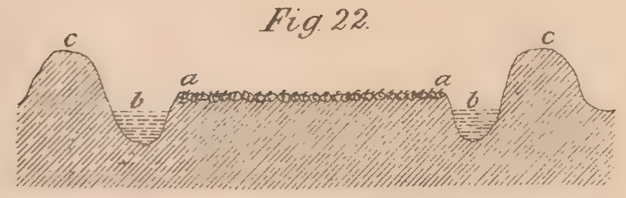


Fig 23.

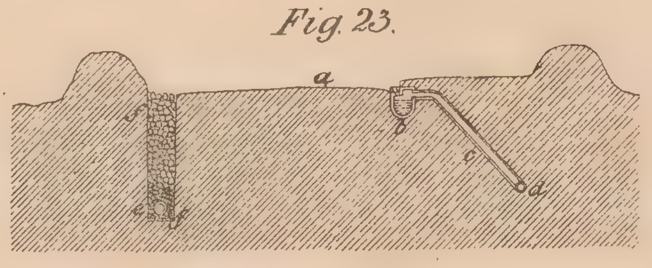


Fig 24.

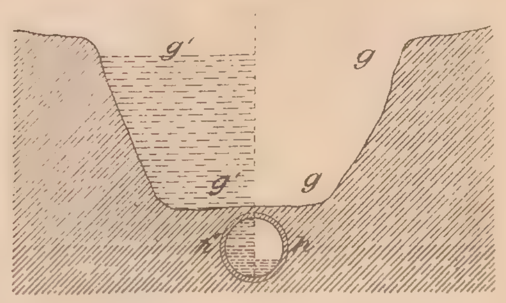


Fig 25.

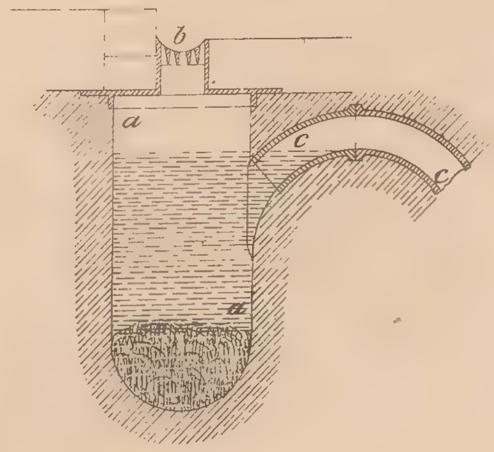


Fig 26.

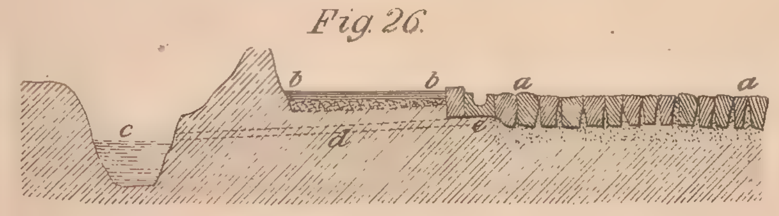
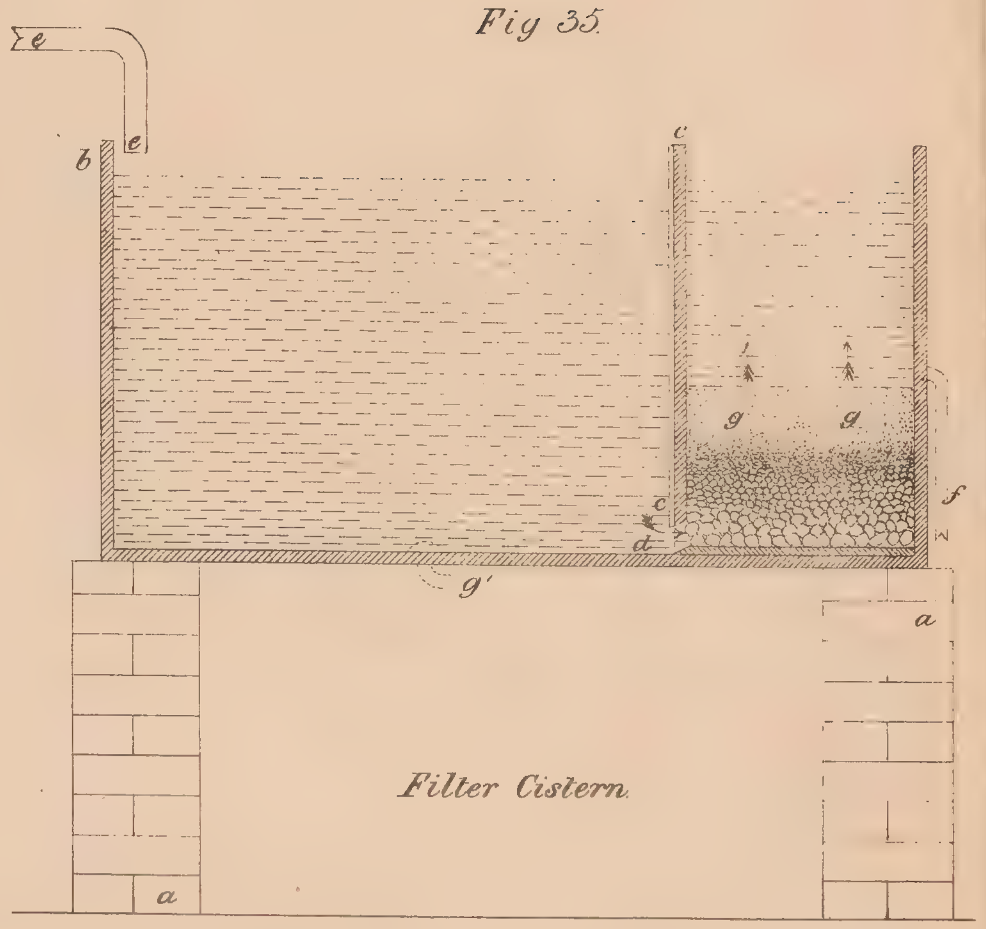
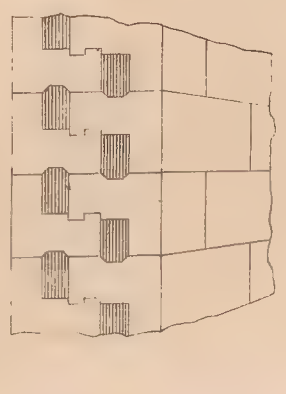


Fig 35.


e
b
c
g
g
d
f
g'
a
a

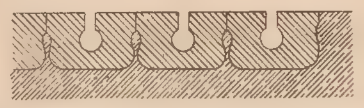
Filter Cistern.

Fig 20.



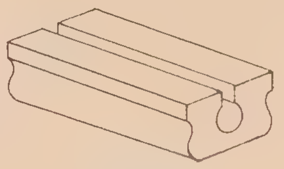
Solid Blocks for Walls.

Fig. 33.



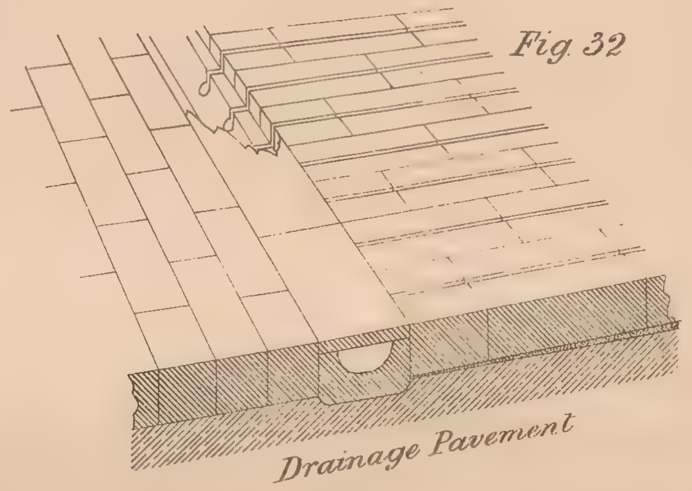
End Elevation of Drain Pavement Bricks.

Fig. 31.



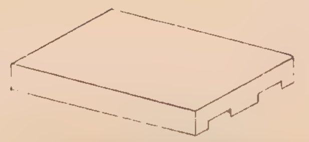
Drain Brick.

Fig 32.



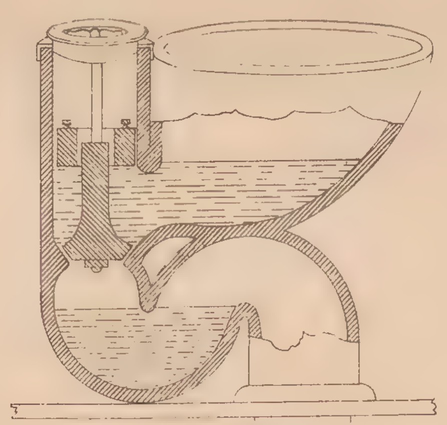
Drainage Pavement

Fig 29.



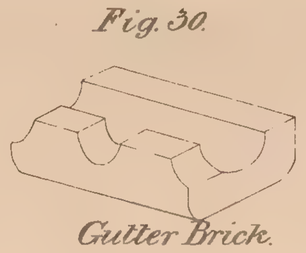
Cover for Gutter.

Fig 36.



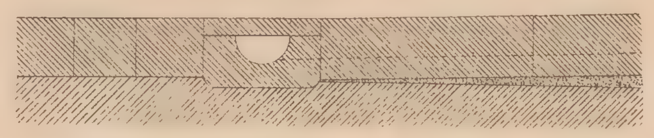
Jennings's Water Closet.

Fig 30.



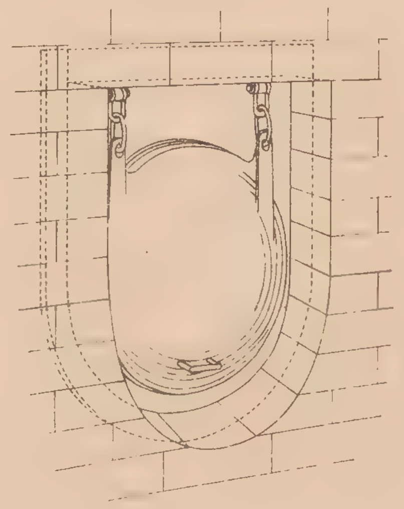
Gutter Brick.

Fig 34.

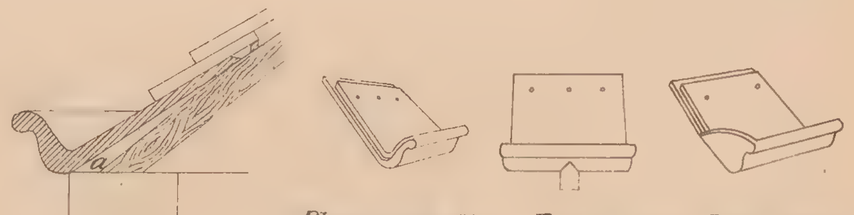


Section of Gutter covered, and slope of Flooring.

Fig 37.

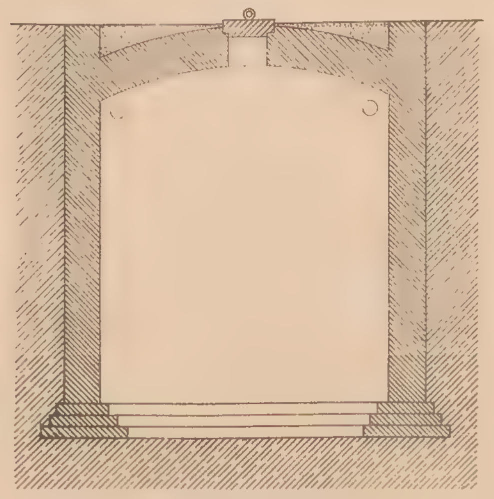


Beadon's Eaves Gutter Tile.

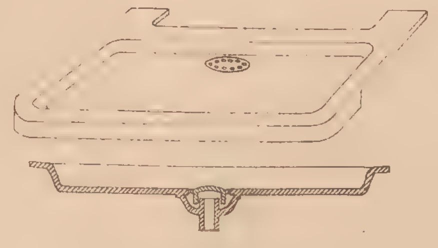


Plain Gutter Tile, 12 to 13 in. long. Ditto with Outlet. Ditto with left stop end.

Fig 28.



Water Cistern.



Newton and Chambers's Kitchen Sink, with Trap.

Fig 39.
Stop-stone.

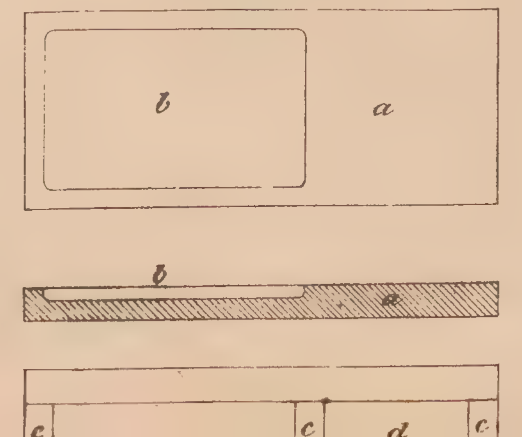


Fig 41.

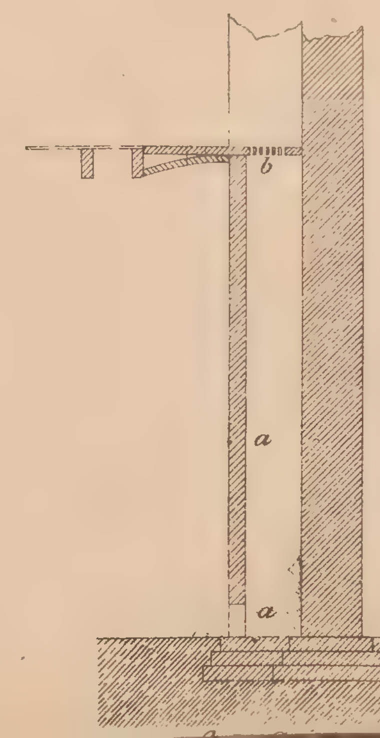
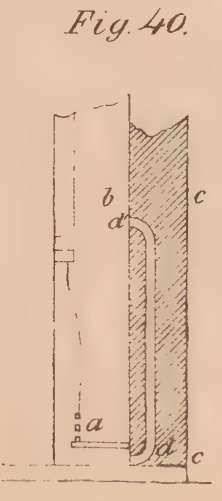


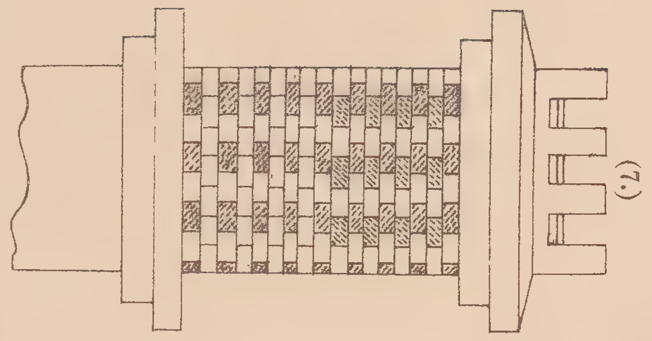
Fig 40.



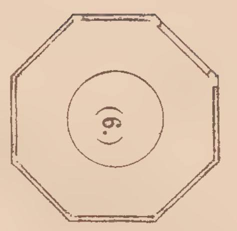
Dust Draught.

DESIGNS FOR CHIMNEY SHAFTS.

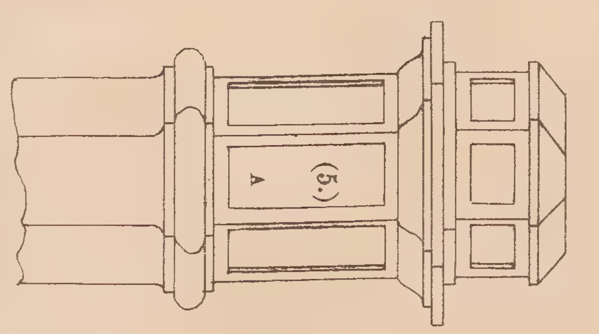
PLATE XXXII.



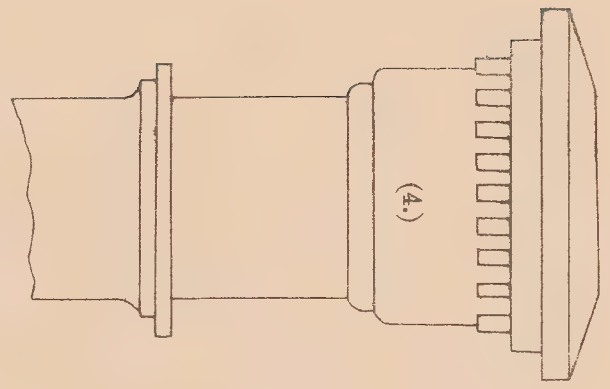
ALTERNATIVE DESIGN FOR TOP OF Fig. 2.



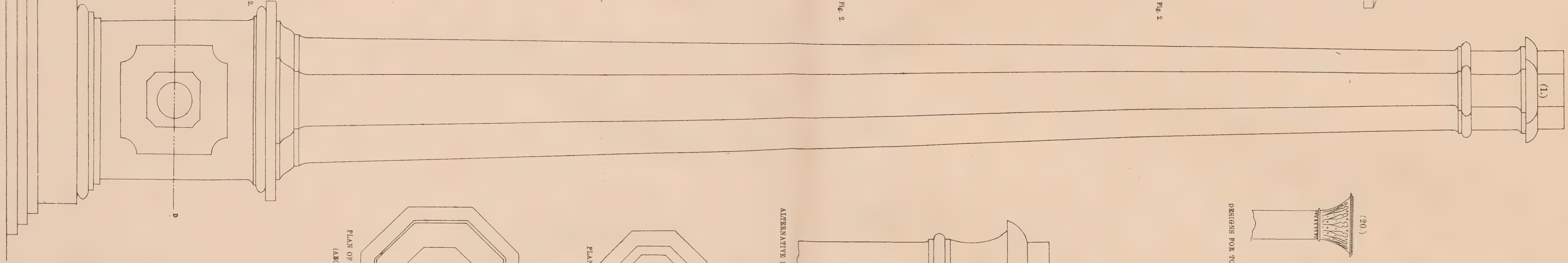
SECTION OF PART A IN Fig. 5.

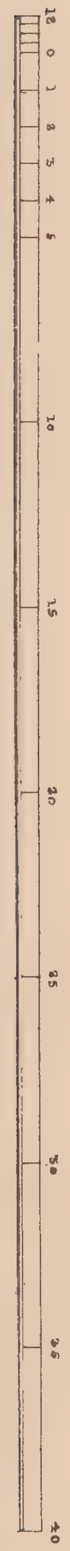


ALTERNATIVE DESIGN FOR TOP OF Fig. 2.

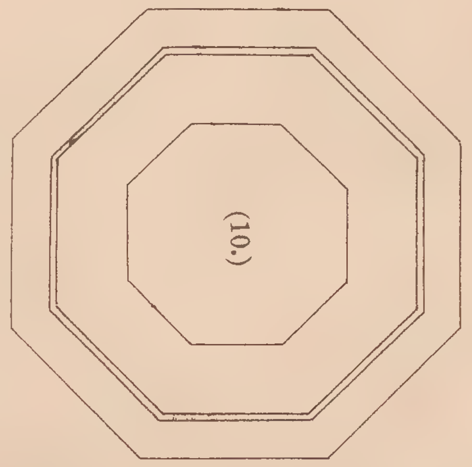


ALTERNATIVE DESIGN FOR TOP OF Fig. 2.

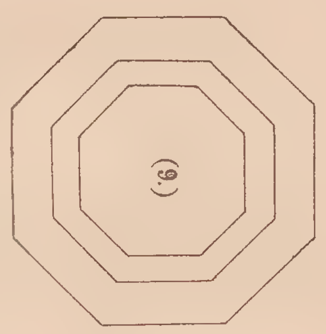



12
0
1
2
3
4
5
10
15
20
25
30
35
40

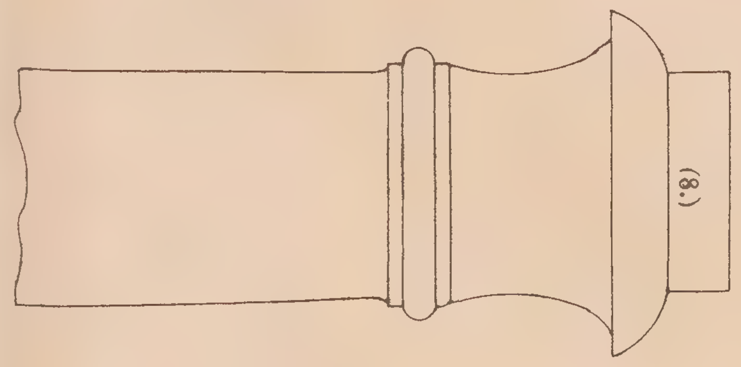
SCALE FOR FIGS. 1 TO 19.



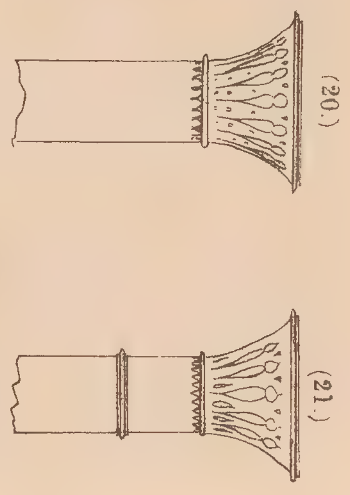
PLAN OF LOWER PART OF SHAFT (ABOVE BASE) IN Fig. 1.



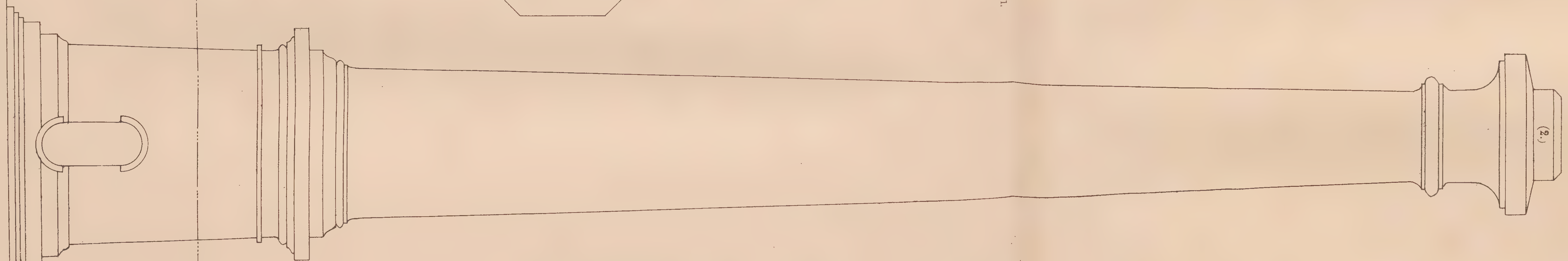
PLAN OF TOP OF Fig. 1

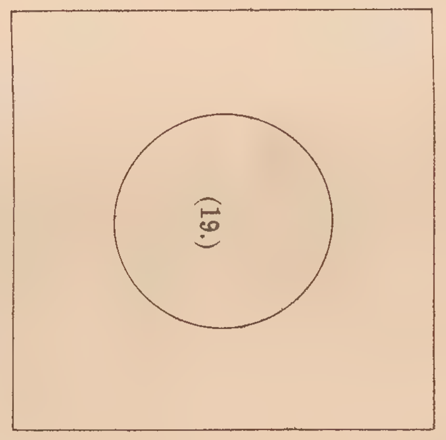


ALTERNATIVE DESIGN FOR TOP OF Fig. 1.

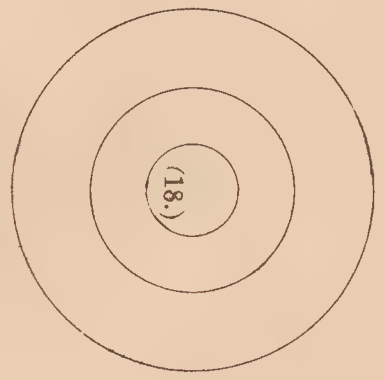


DESIGNS FOR TOPS OF IRON CHIMNEYS.

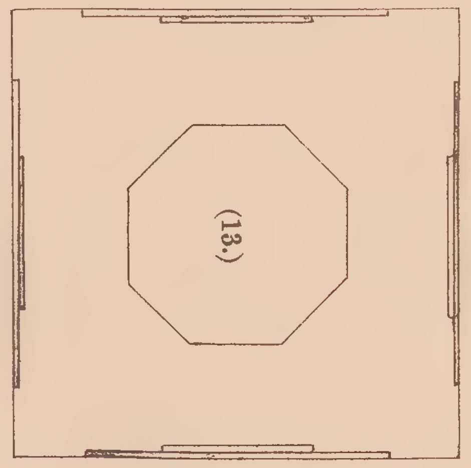




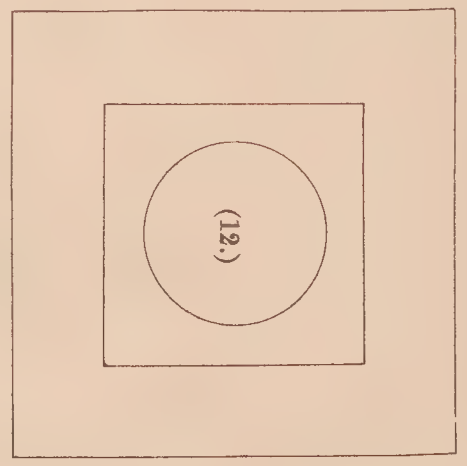
SECTION AT LINE A B, Fig. 2.



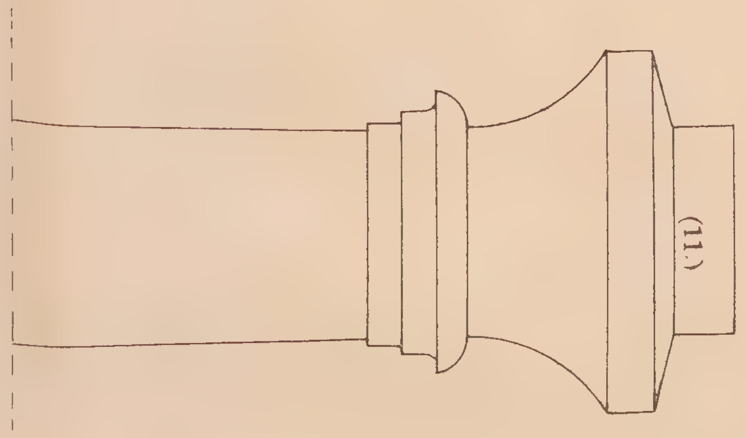
PLAN OF TOP OF Fig. 2



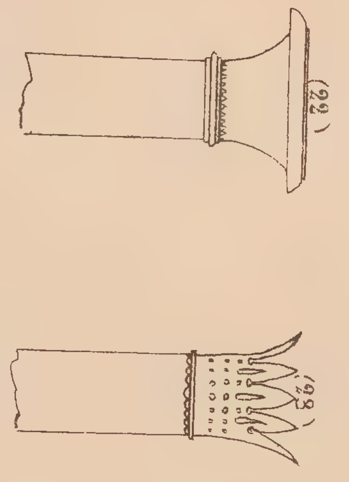
SECTION ON LINE C D, Fig. 1.



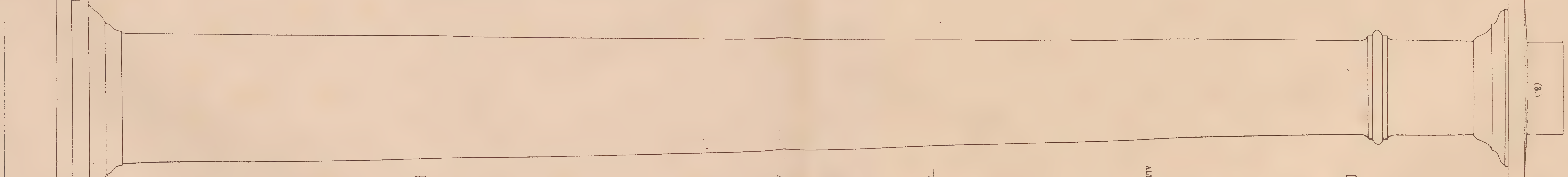
PLAN OF TOP OF Fig. 3.

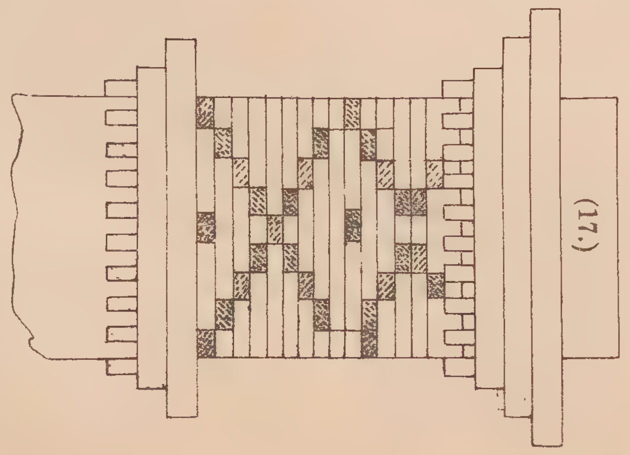


ALTERNATIVE DESIGN FOR TOP OF Fig. 2.

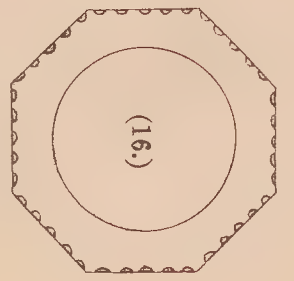


DESIGNS FOR TOPS OF IRON CHIMNEYS.

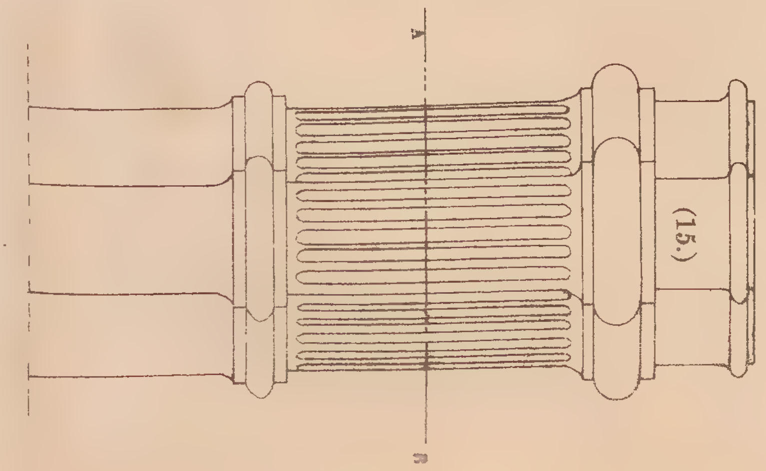




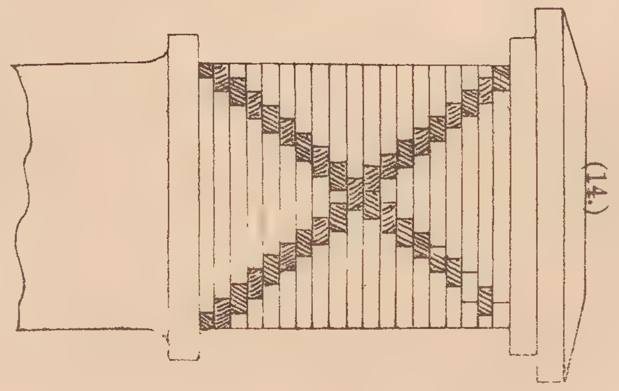
ALTERNATIVE DESIGN FOR TOP OF Fig. 3



SECTION ON LINE A B, Fig. 15.



ALTERNATIVE DESIGN FOR TOP OF Fig. 3.

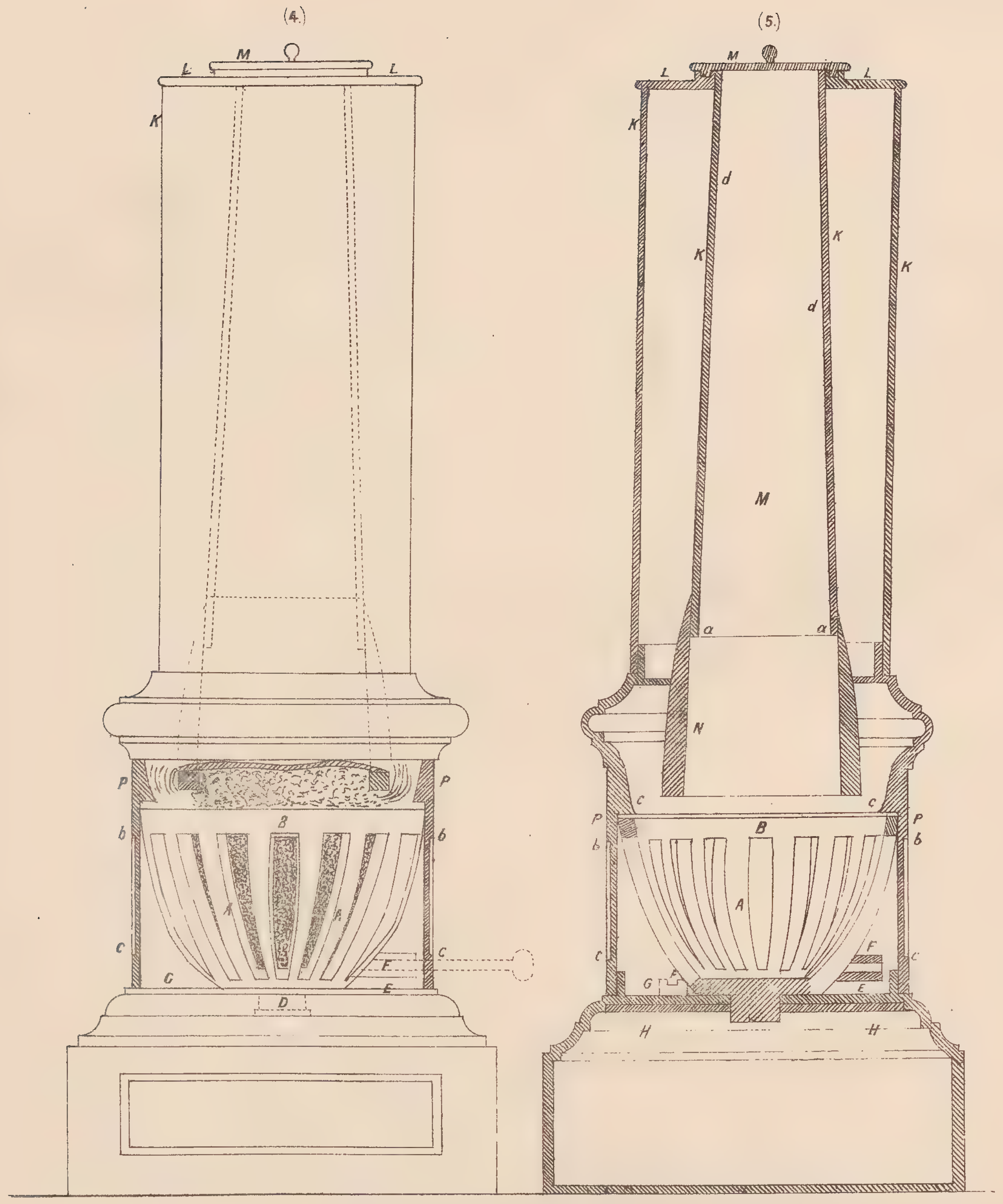


ALTERNATIVE DESIGN FOR TOP OF Fig. 3.

WARMING AND VENTILATING APPARATUS.

PLATE XXXIII.

(4) (5)



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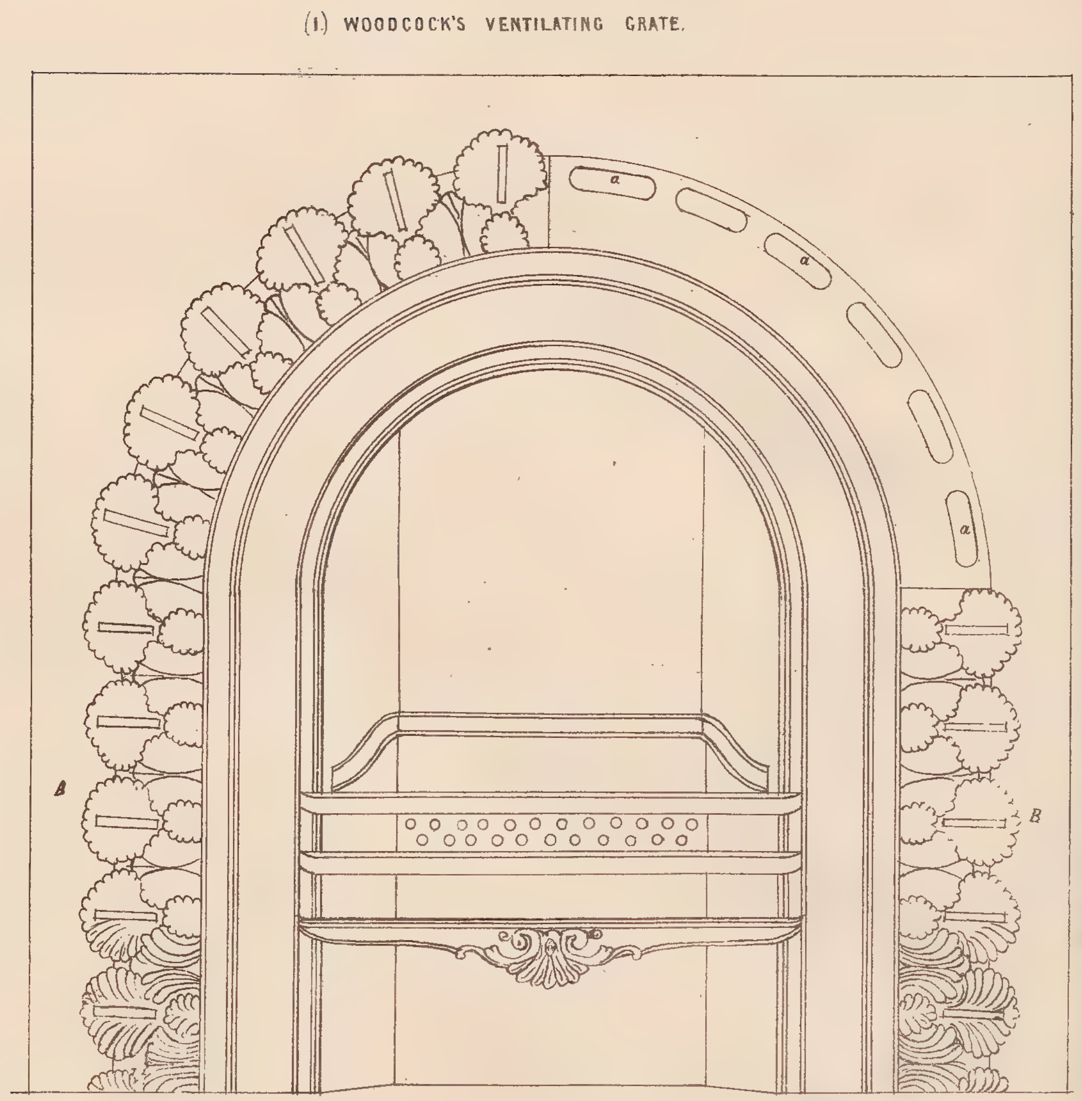
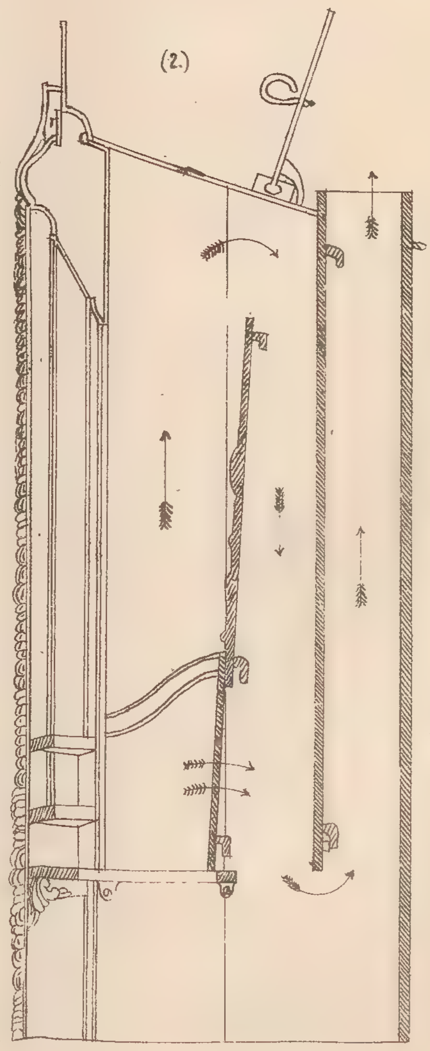
RUSSELL'S OPEN FIREPLACE STOVE.

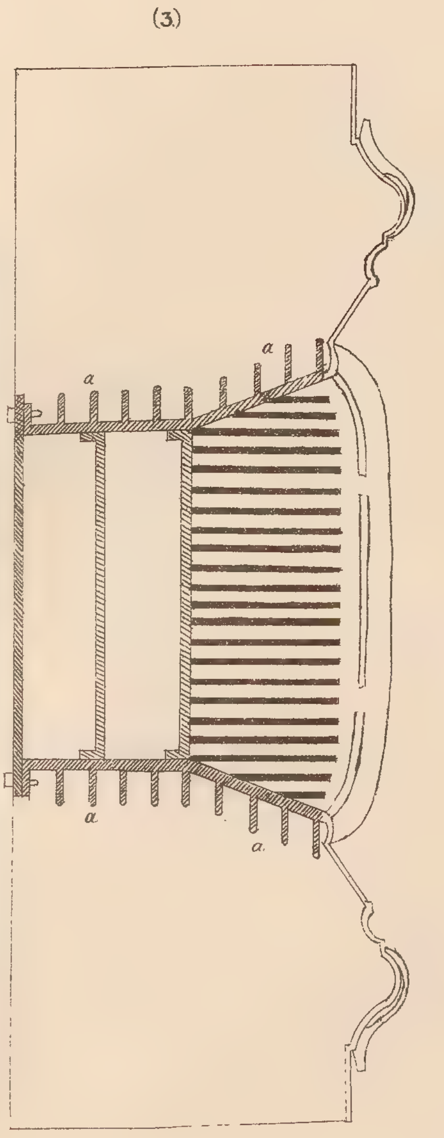
(1) WOODCOCK'S VENTILATING GRATE.



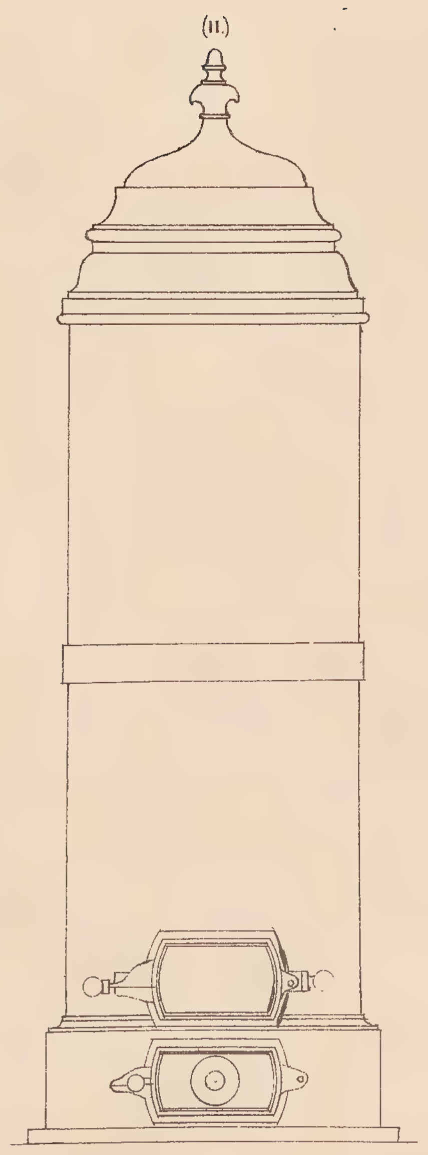
(2)



(3)

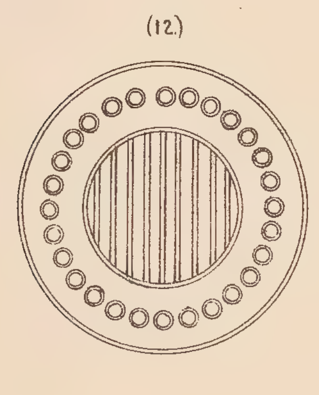


(11)

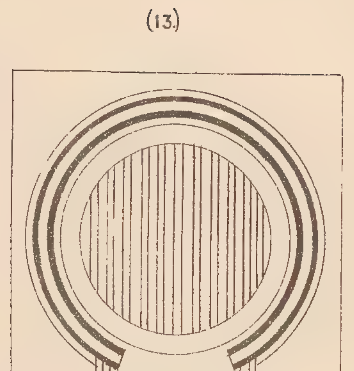


WALKER'S SELF-FEEDING HOT WATER BOILER.

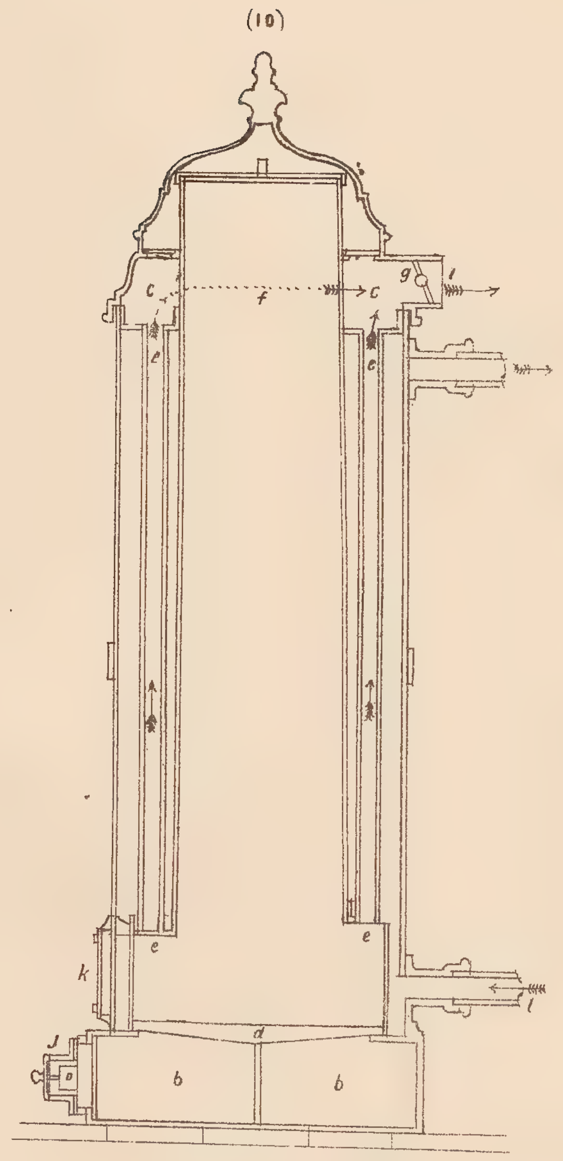
(12)



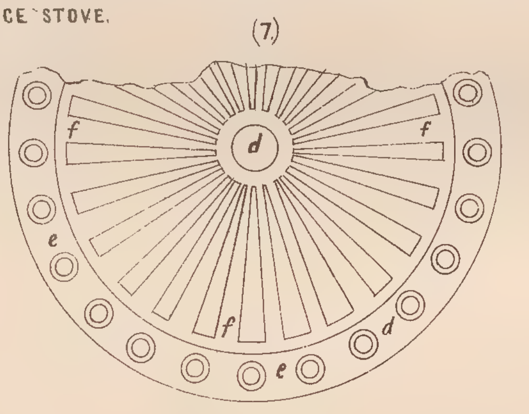
(13)



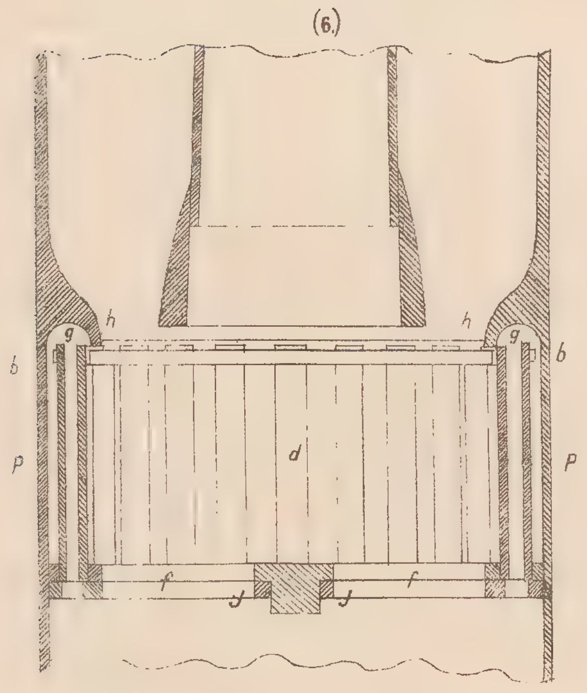
(10)



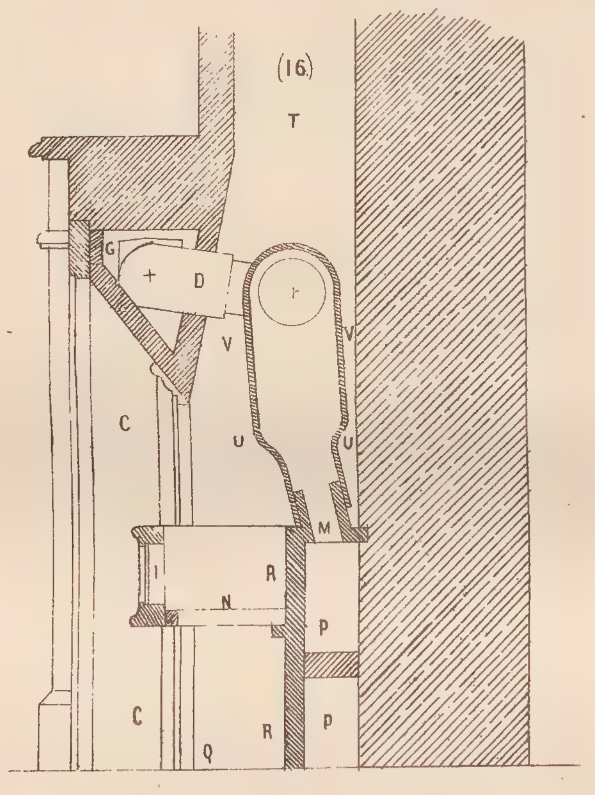
(7)



(6)



(16)



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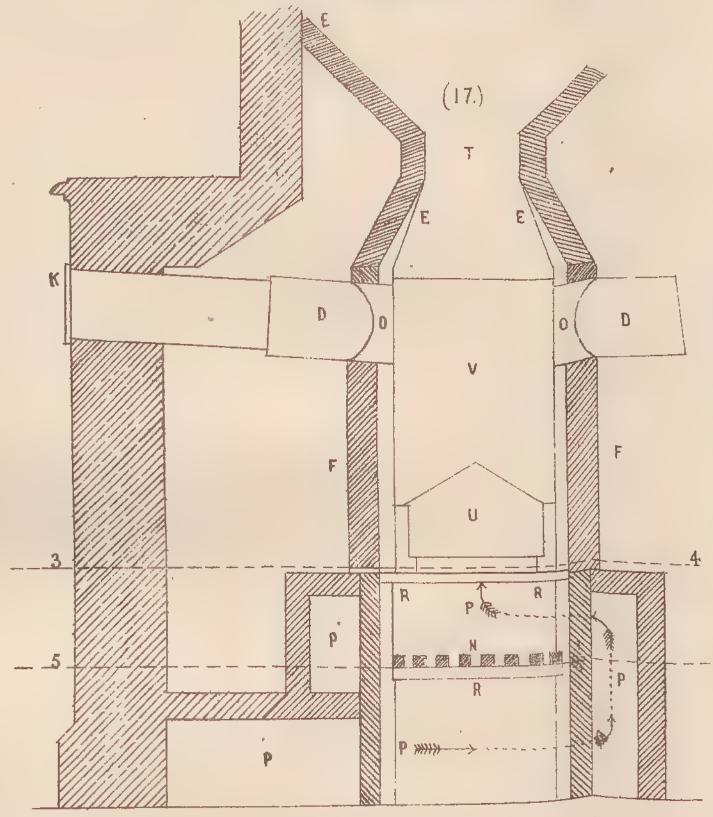
(17)



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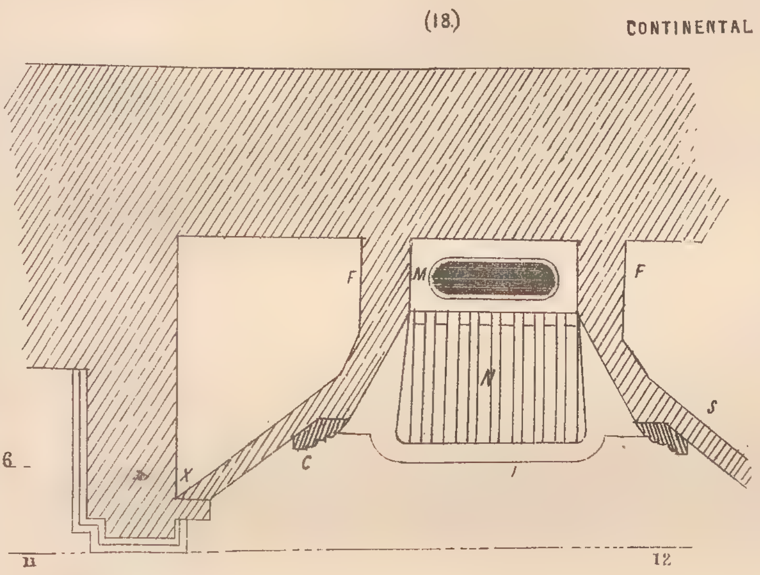
CONTINENTAL STOVE.

(18)



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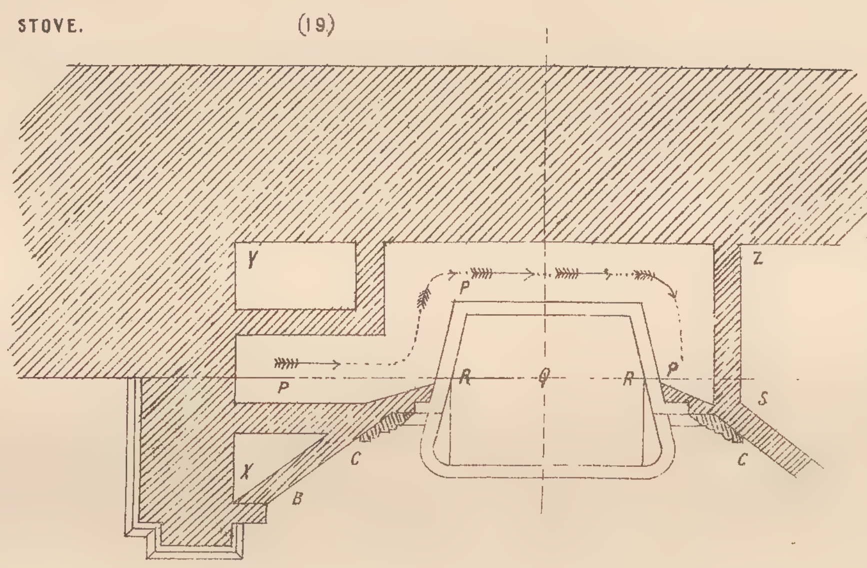
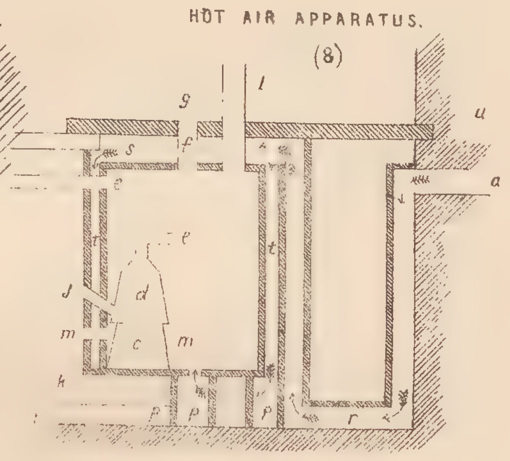
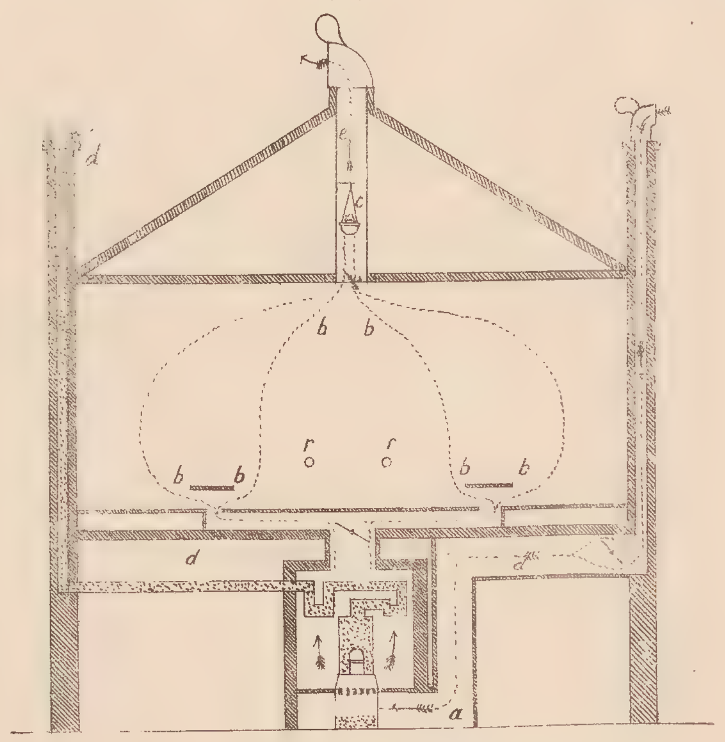
(19)



HOT AIR APPARATUS. (8)



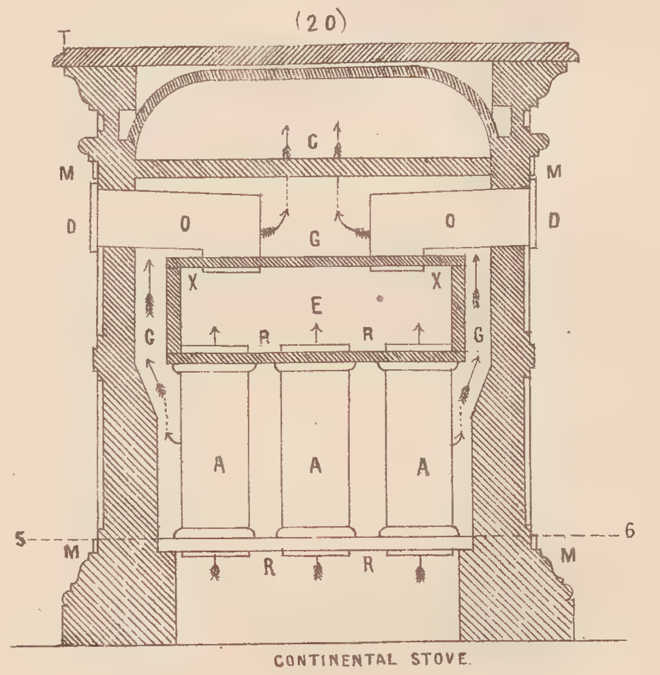
(23)



AMERICAN SCHOOL WARMING & VENTILATING

CONTINENTAL STOVE.

(20)



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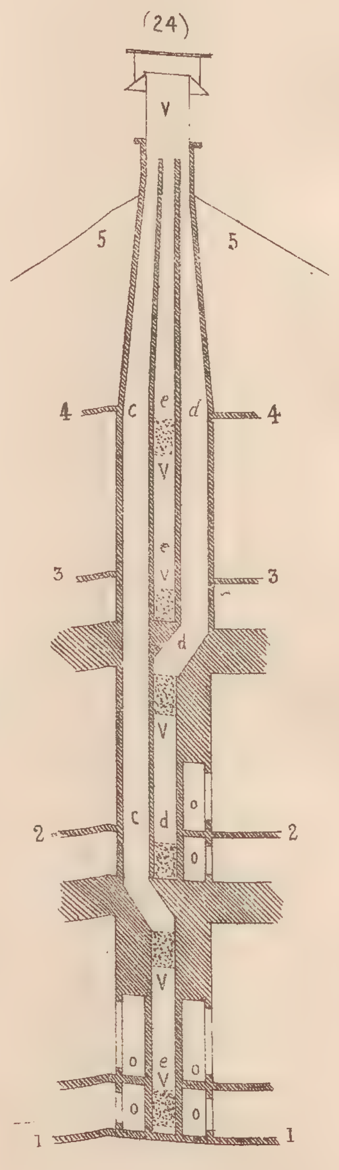
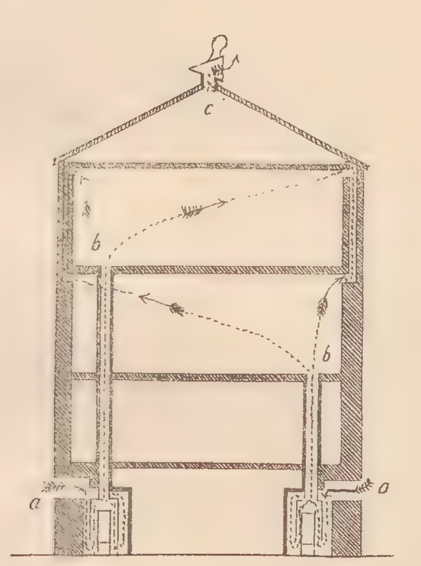
CONTINENTAL STOVE.

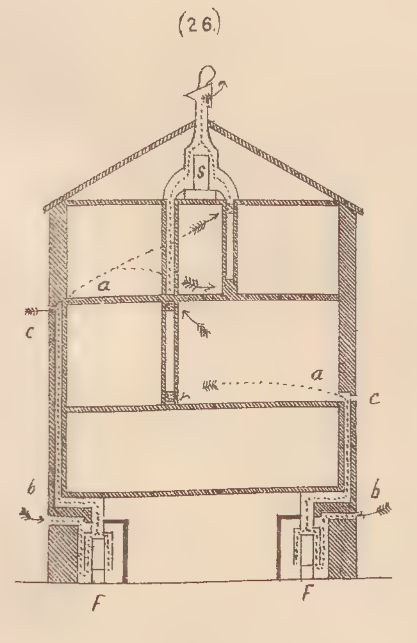
(24)



(25)

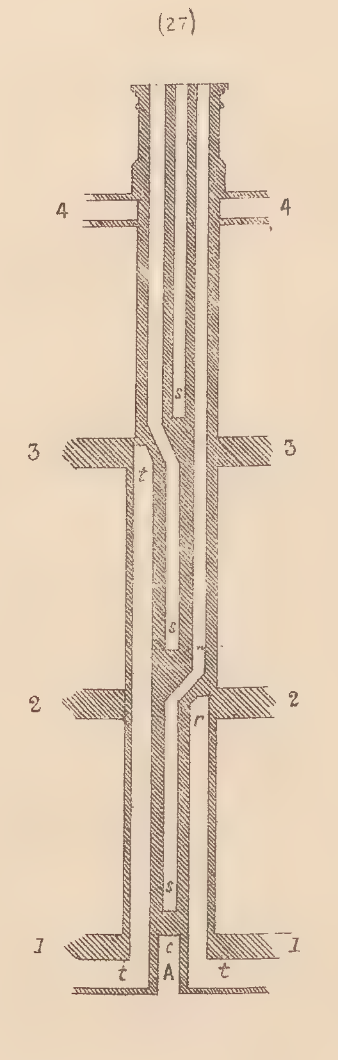


(26)

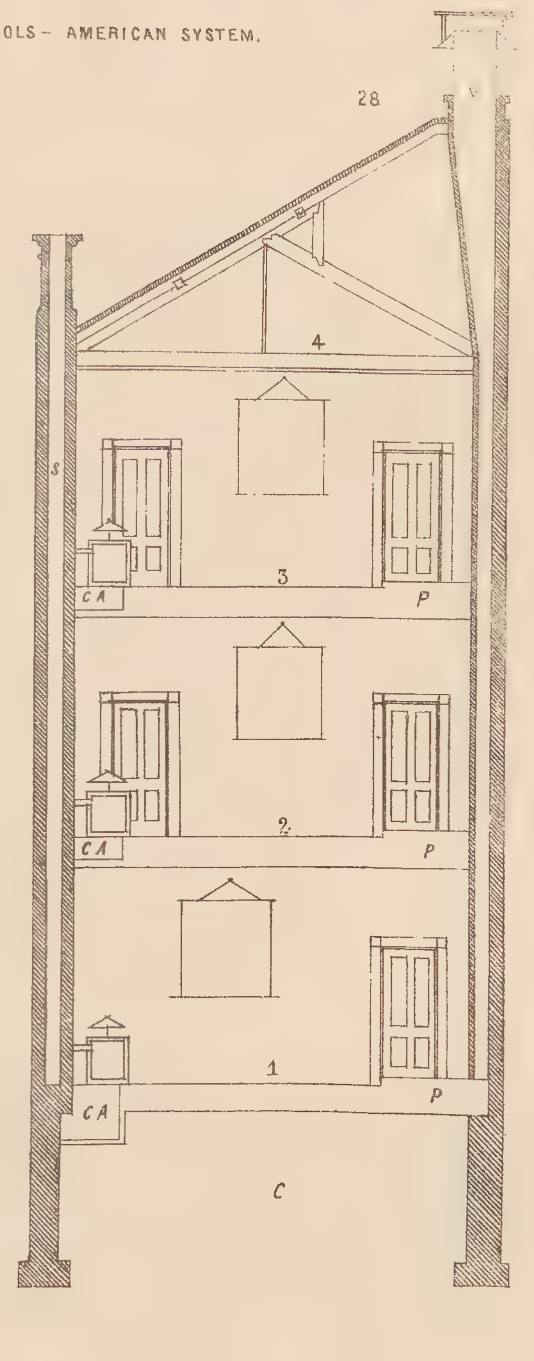


WARMING & VENTILATING SCHOOLS- AMERICAN SYSTEM.

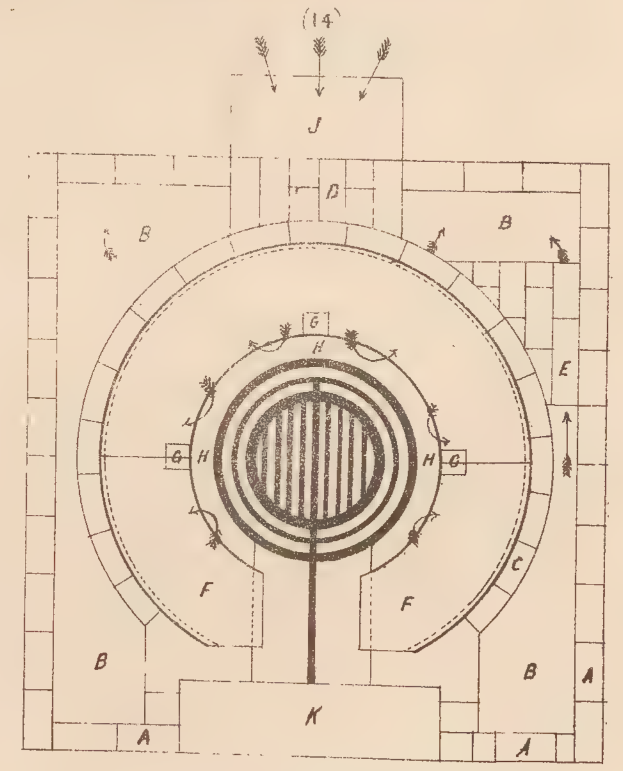
(27)



28



(14)



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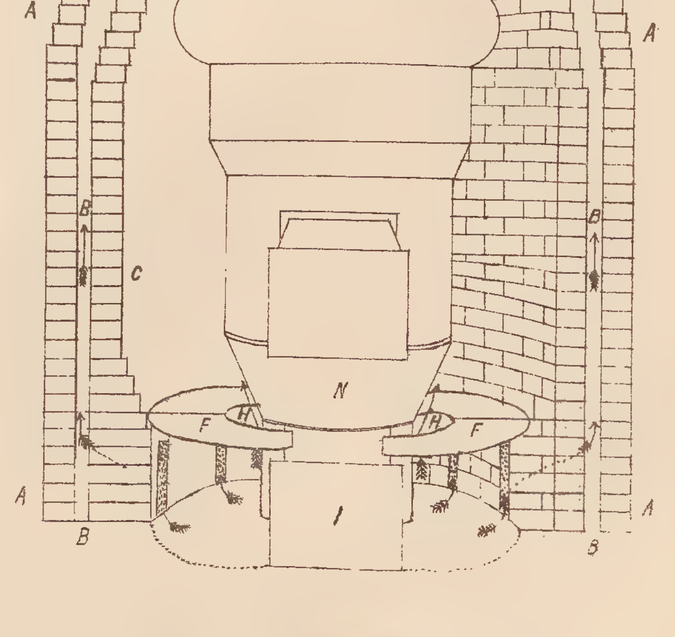
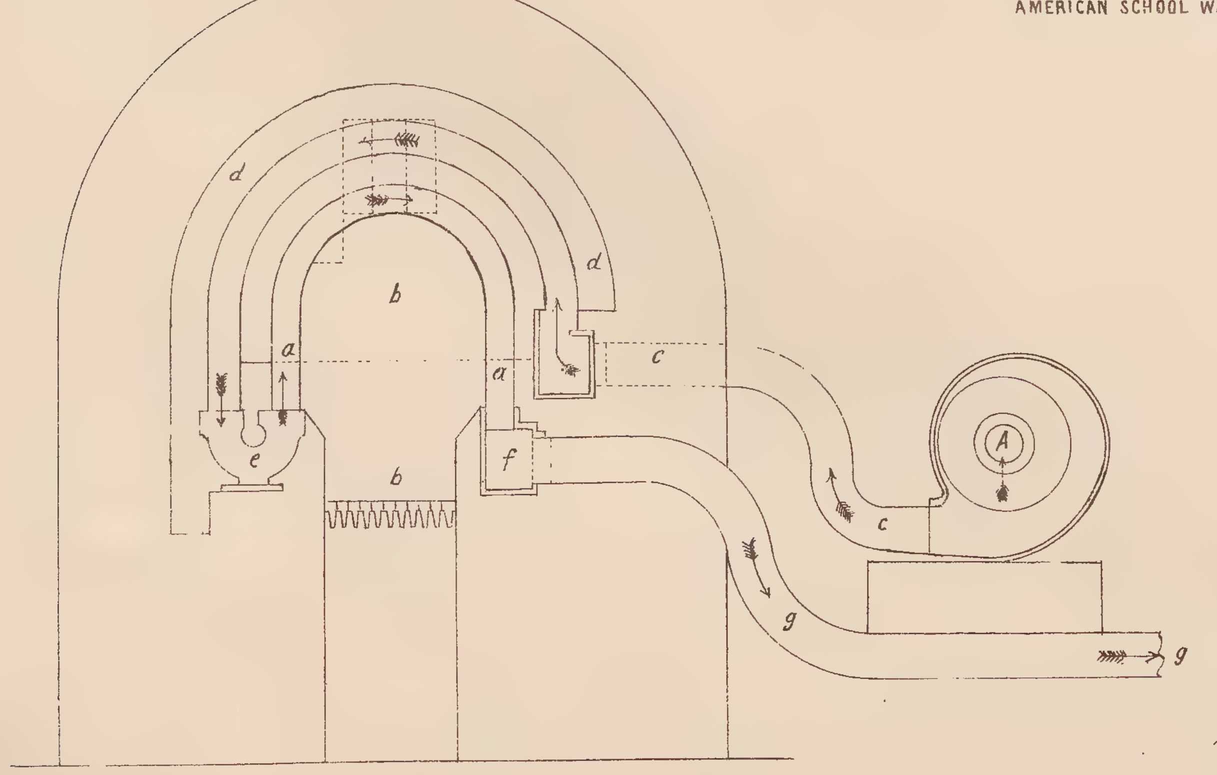
AMERICAN (CHILSON'S) HOT AIR STOVE.

(15)

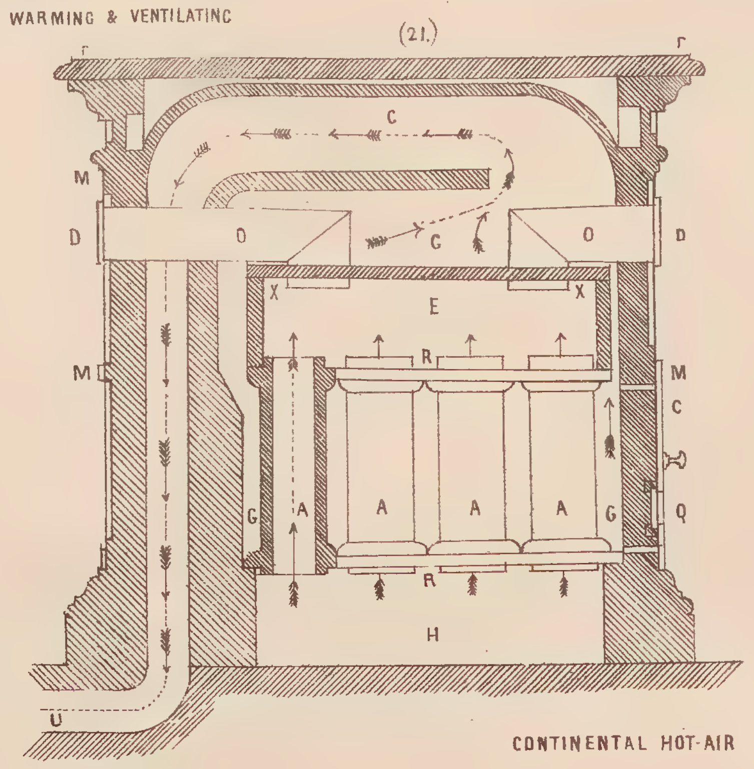


(9)

DAVISON'S HOT-AIR VENTILATING APPARATUS.



(21.)



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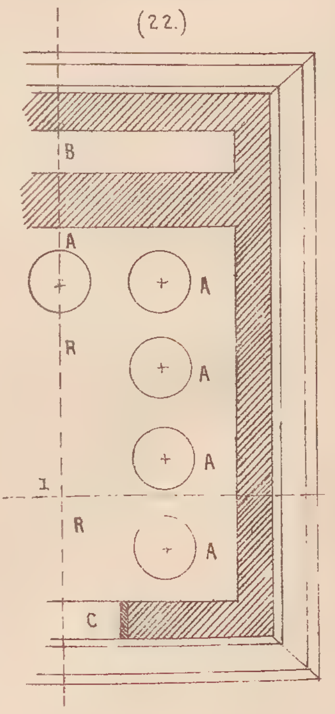
(22.)



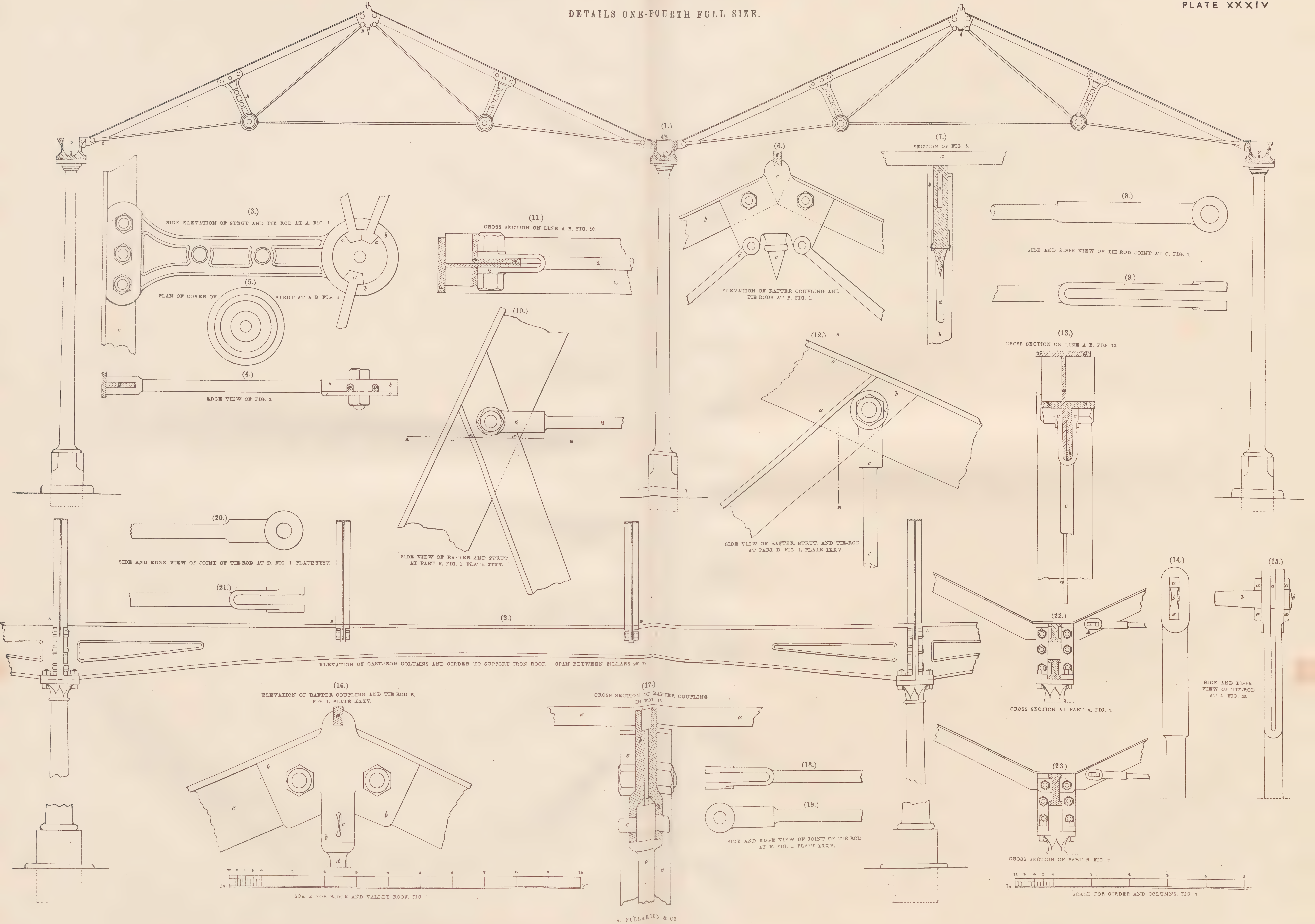
CONTINENTAL HOT-AIR STOVE.

A. FULLARTON & CO. LONDON AND EDINBURGH.

IRON RIDGE-AND-VALLEY ROOF SUPPORTED ON CAST-IRON COLUMNS.

DETAILS ONE-FOURTH FULL SIZE.

PLATE XXXIV



SIDE ELEVATION OF STRUT AND TIE ROD AT A. FIG. 1

PLAN OF COVER OF STRUT AT A B. FIG. 3

EDGE VIEW OF FIG. 3.

CROSS SECTION ON LINE A B. FIG. 10.

SIDE VIEW OF RAFTER AND STRUT AT PART F. FIG. 1. PLATE XXXV.

ELEVATION OF RAFTER COUPLING AND TIE-RODS AT B. FIG. 1.

SECTION OF FIG. 6.

SIDE AND EDGE VIEW OF TIE-ROD JOINT AT C. FIG. 1.

SIDE VIEW OF RAFTER, STRUT, AND TIE-ROD AT PART D. FIG. 1. PLATE XXXV.

CROSS SECTION ON LINE A B. FIG. 12.

SIDE AND EDGE VIEW OF JOINT OF TIE-ROD AT D. FIG. 1. PLATE XXXV.

ELEVATION OF CAST-IRON COLUMNS AND GIRDER, TO SUPPORT IRON ROOF. SPAN BETWEEN PILLARS 22′ 7″.

CROSS SECTION AT PART A. FIG. 2.

SIDE AND EDGE. VIEW OF TIE-ROD AT A. FIG. 20.

ELEVATION OF RAFTER COUPLING AND TIE-ROD B. FIG. 1. PLATE XXXV.

CROSS SECTION OF RAFTER COUPLING IN FIG. 16.

SIDE AND EDGE VIEW OF JOINT OF TIE ROD AT F. FIG. 1. PLATE XXXV.

CROSS SECTION OF PART B. FIG. 2

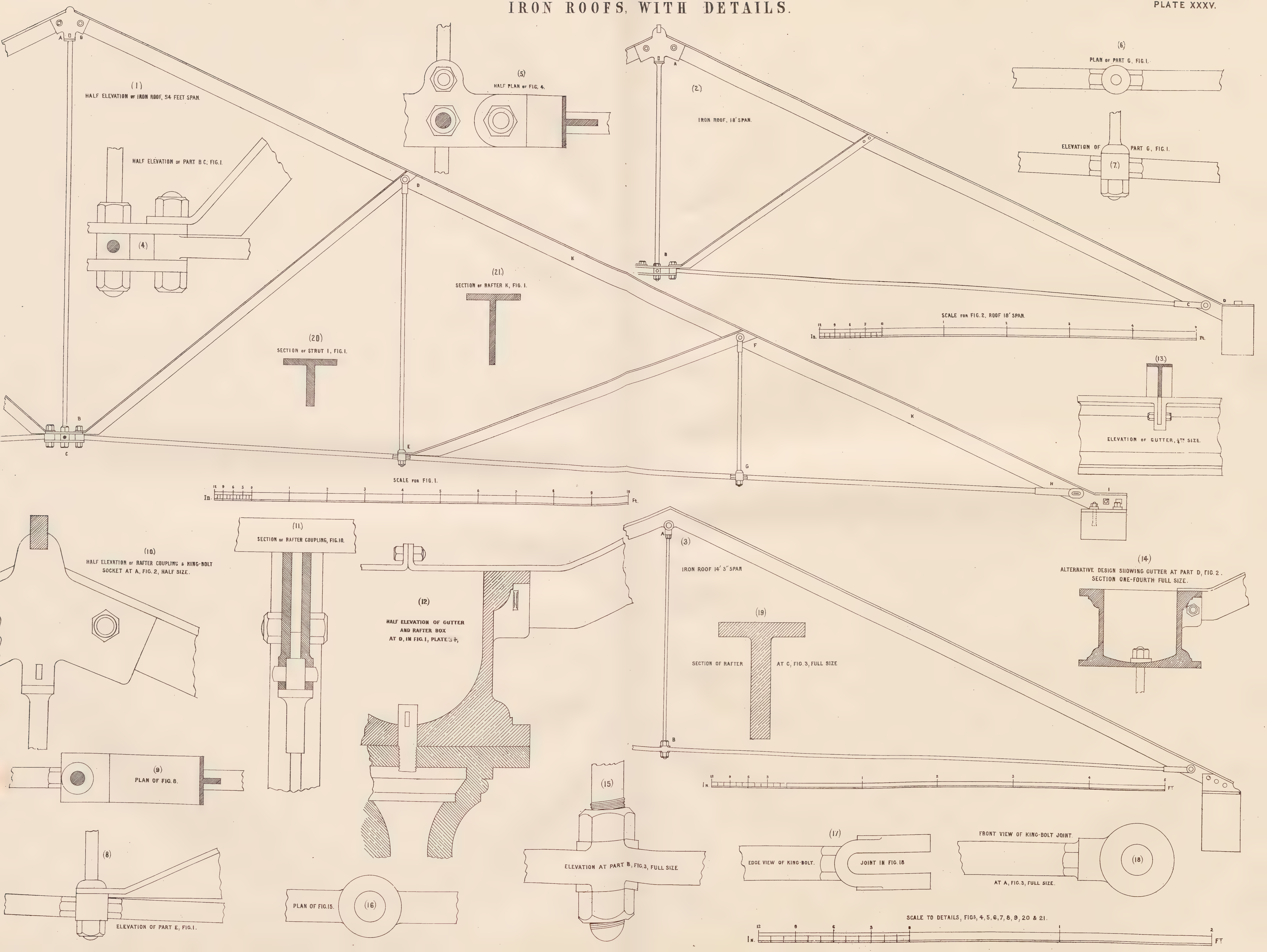
SCALE FOR RIDGE AND VALLEY ROOF. FIG 1

SCALE FOR GIRDER AND COLUMNS. FIG 2

A. FULLARTON & CO

IRON ROOFS, WITH DETAILS.

PLATE XXXV.



(1) HALF ELEVATION OF IRON ROOF, 54 FEET SPAN.

(2) IRON ROOF, 18' SPAN.

(3) IRON ROOF 14' 3" SPAN

(4) HALF ELEVATION OF PART B C, FIG. I.

(5) HALF PLAN OF FIG. 4.

(6) PLAN OF PART G, FIG. I.

(7) ELEVATION OF PART G, FIG. I.

(8) ELEVATION OF PART E, FIG. I.

(9) PLAN OF FIG. 8.

(10) HALF ELEVATION OF RAFTER COUPLING & KING-BOLT SOCKET AT A, FIG. 2, HALF SIZE.

(11) SECTION OF RAFTER COUPLING, FIG. 10.

(12) HALF ELEVATION OF GUTTER AND RAFTER BOX AT D, IN FIG. I, PLATE 34,

(13) ELEVATION OF GUTTER, ¼TH SIZE.

(14) ALTERNATIVE DESIGN SHOWING GUTTER AT PART D, FIG. 2. SECTION ONE-FOURTH FULL SIZE.

(15) ELEVATION AT PART B, FIG. 3, FULL SIZE

(16) PLAN OF FIG. 15.

(17) EDGE VIEW OF KING-BOLT. JOINT IN FIG. 18

(18) FRONT VIEW OF KING-BOLT JOINT AT A, FIG. 3, FULL SIZE.

(19) SECTION OF RAFTER AT C, FIG. 3, FULL SIZE

(20) SECTION OF STRUT I, FIG. I.

(21) SECTION OF RAFTER K, FIG. I.

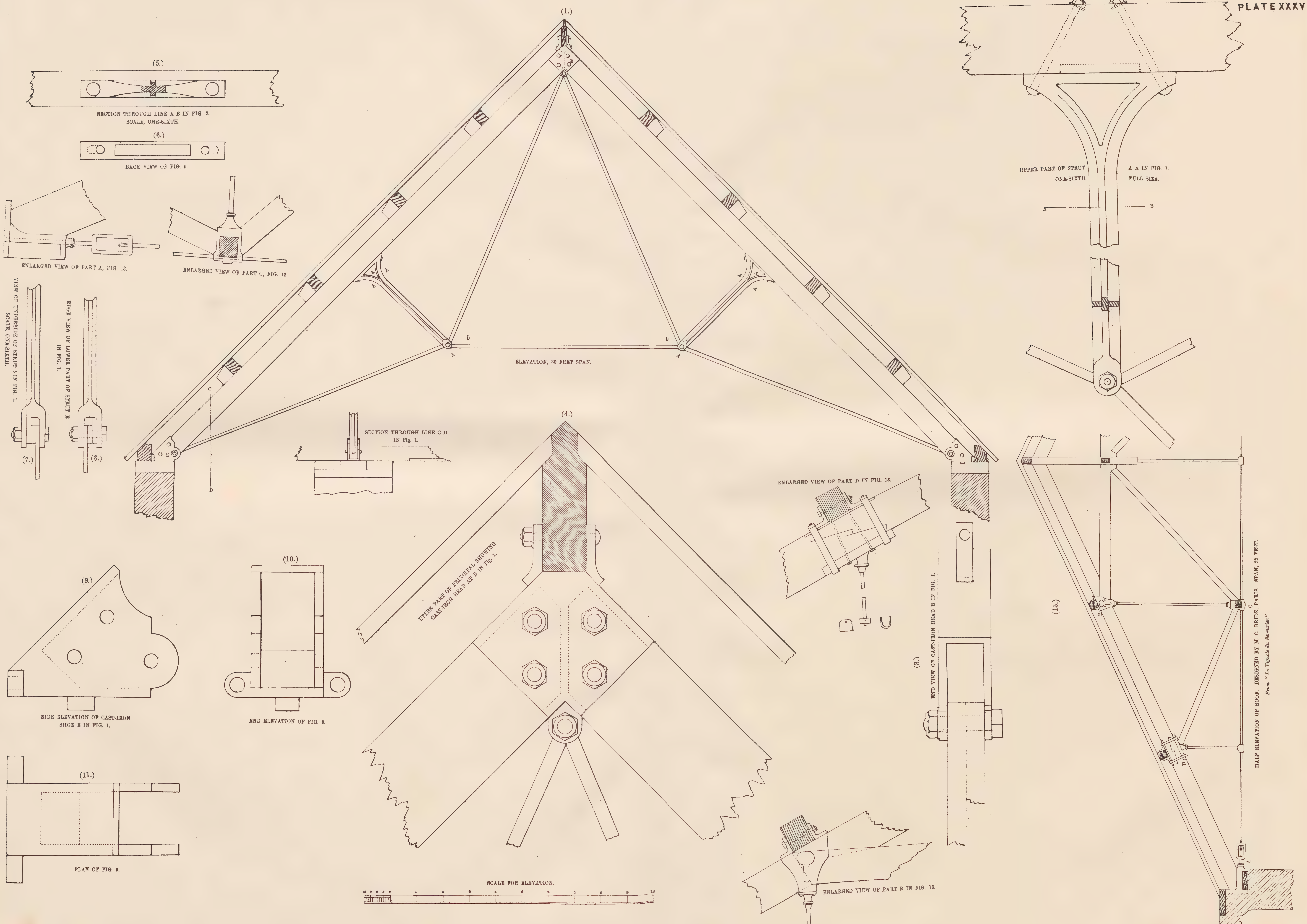
SCALE FOR FIG. I.

SCALE FOR FIG. 2, ROOF 18' SPAN.

SCALE TO DETAILS, FIGS. 4, 5, 6, 7, 8, 9, 20 & 21.

TIMBER AND IRON ROOFS.

PLATE XXXVI.



ELEVATION, 30 FEET SPAN.

SECTION THROUGH LINE A B IN FIG. 2.
SCALE, ONE-SIXTH.

BACK VIEW OF FIG. 5.

ENLARGED VIEW OF PART A, FIG. 13.

ENLARGED VIEW OF PART C, FIG. 13.

VIEW OF UNDERSIDE OF STRUT *b* IN FIG. 1.
SCALE, ONE-SIXTH.

EDGE VIEW OF LOWER PART OF STRUT B
IN FIG. 1.

UPPER PART OF STRUT A A IN FIG. 1.
ONE-SIXTH FULL SIZE.

SECTION THROUGH LINE C D
IN Fig. 1.

UPPER PART OF PRINCIPAL SHOWING
CAST-IRON HEAD AT B IN Fig. 1.

ENLARGED VIEW OF PART D IN FIG. 13.

END VIEW OF CAST-IRON HEAD B IN FIG. 1.

SIDE ELEVATION OF CAST-IRON
SHOE E IN FIG. 1.

END ELEVATION OF FIG. 9.

PLAN OF FIG. 9.

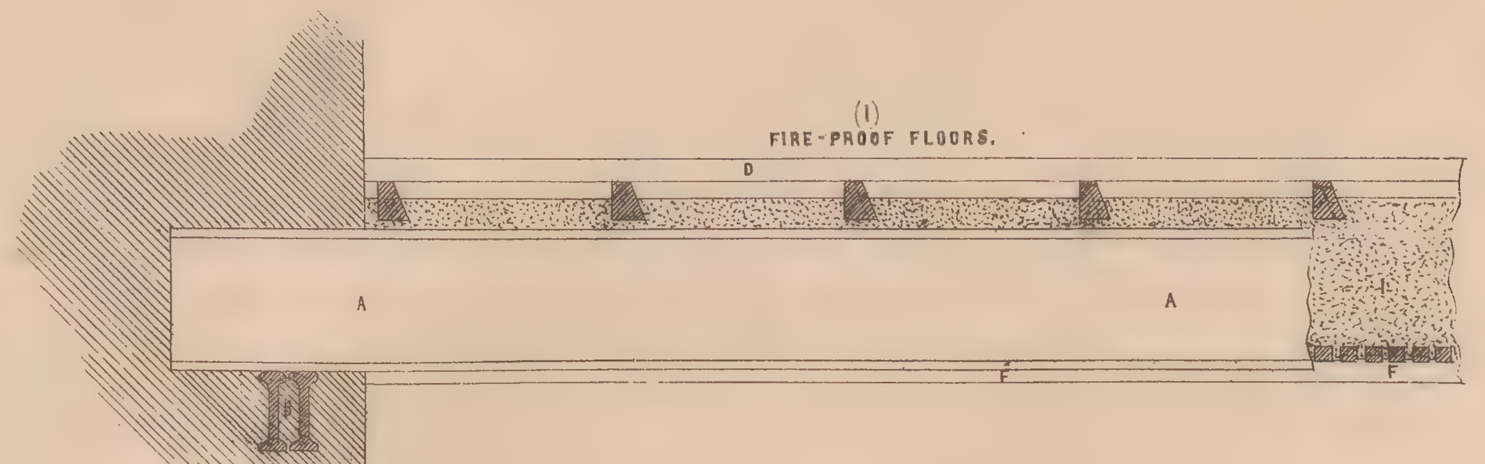
SCALE FOR ELEVATION.

ENLARGED VIEW OF PART B IN FIG. 13.

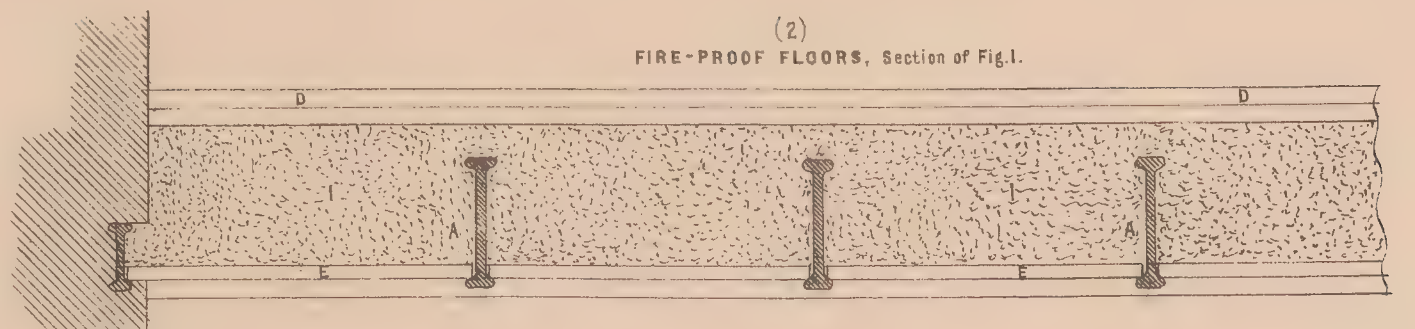
HALF ELEVATION OF ROOF. DESIGNED BY M. C. BRIDE, PARIS. SPAN, 32 FEET.
From "Le Vignole du Serrurier."

A. FULLARTON & Co LONDON & EDINBURGH

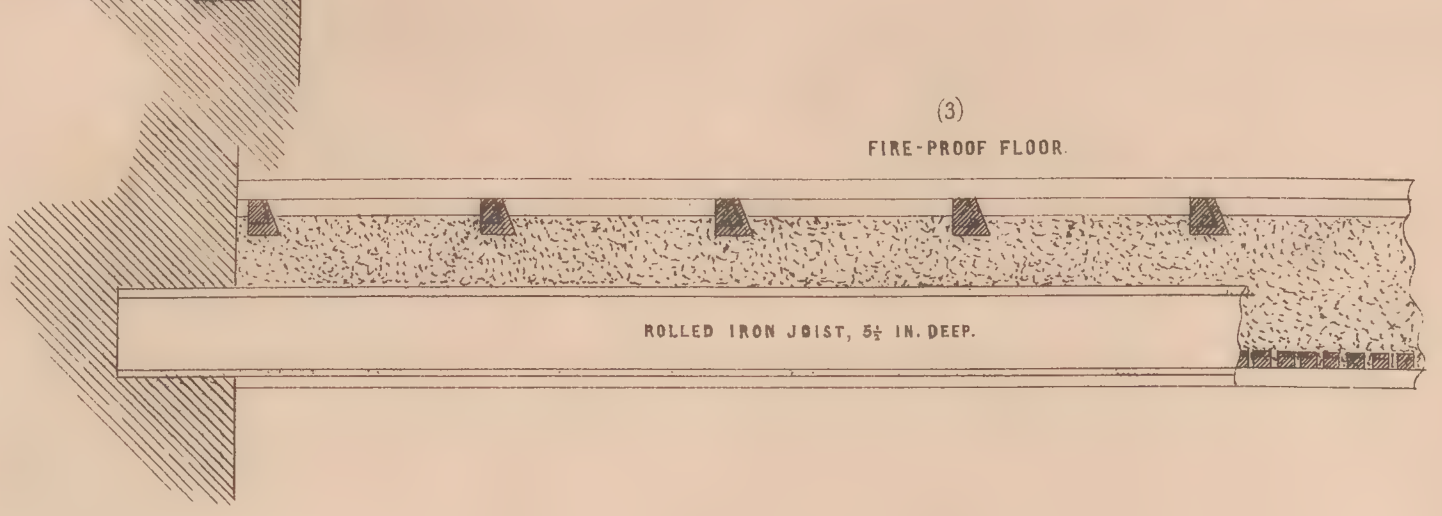
FIRE PROOF AND OTHER FLOORS. BRITISH AND CONTINENTAL SYSTEMS.



(1) FIRE-PROOF FLOORS.

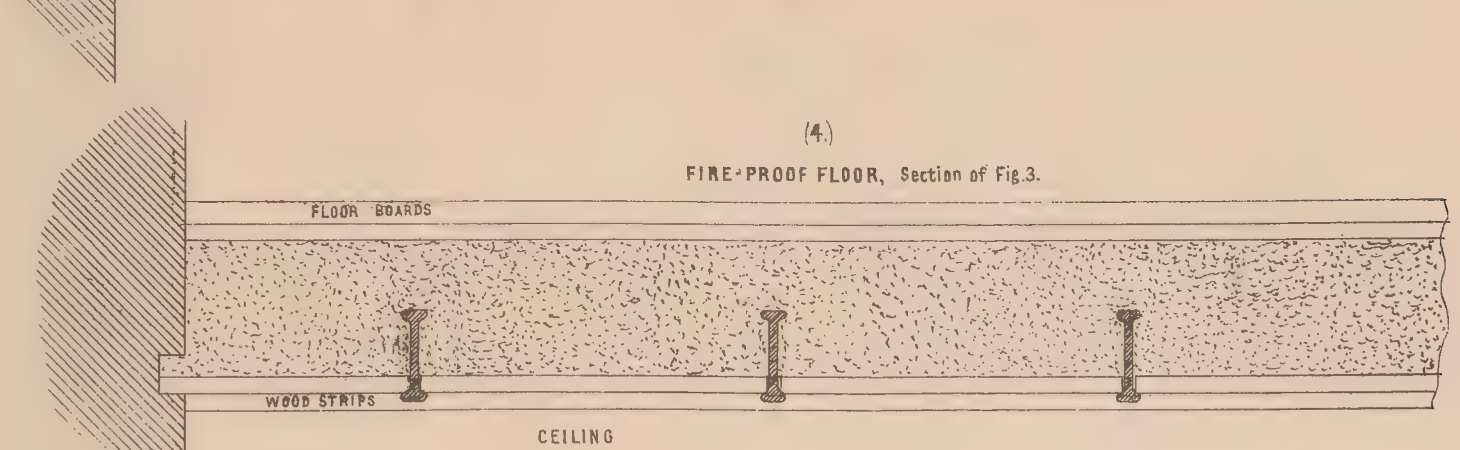


(2) FIRE-PROOF FLOORS, Section of Fig.1.



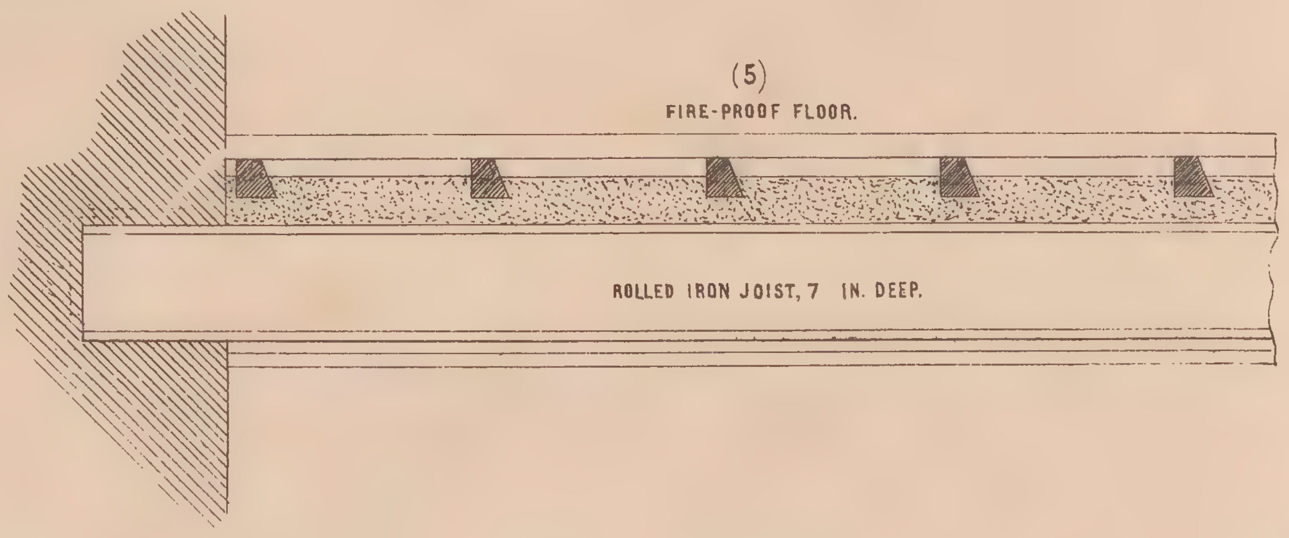
(3) FIRE-PROOF FLOOR

ROLLED IRON JOIST, 5½ IN. DEEP.



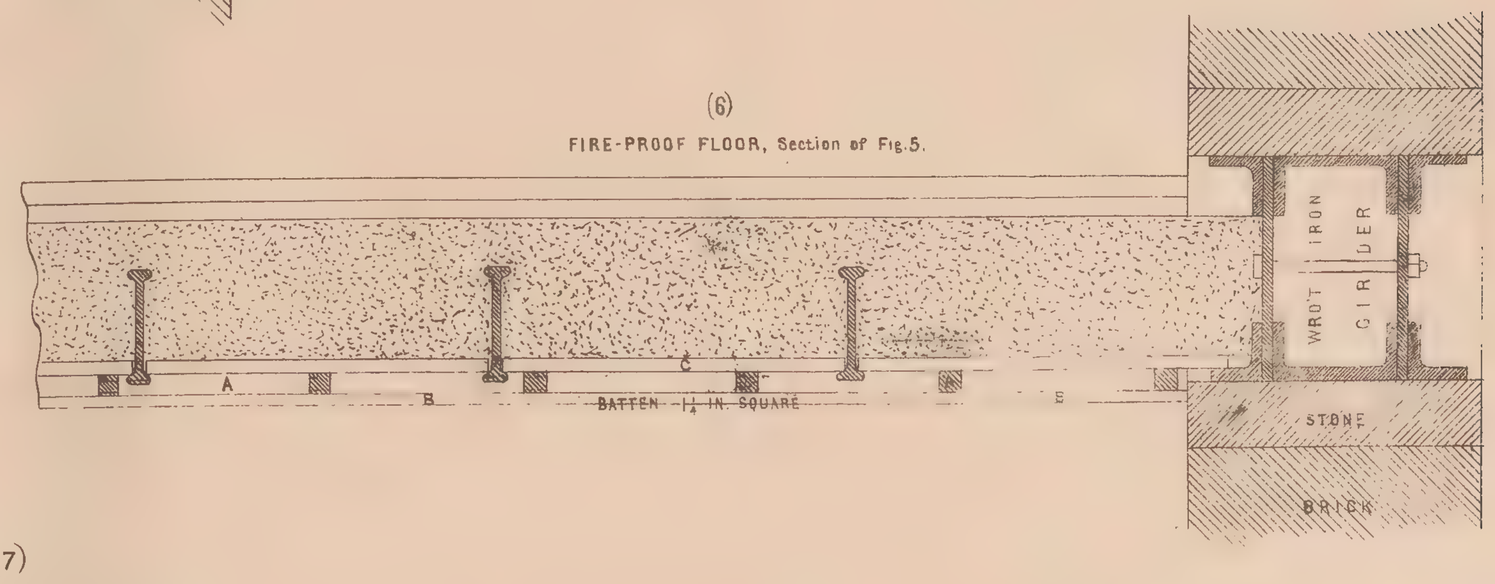
(4.) FIRE-PROOF FLOOR, Section of Fig.3.

FLOOR BOARDS
WOOD STRIPS
CEILING



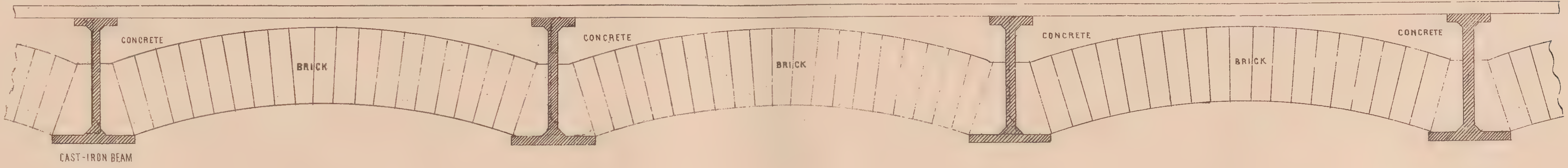
(5) FIRE-PROOF FLOOR.

ROLLED IRON JOIST, 7 IN. DEEP.



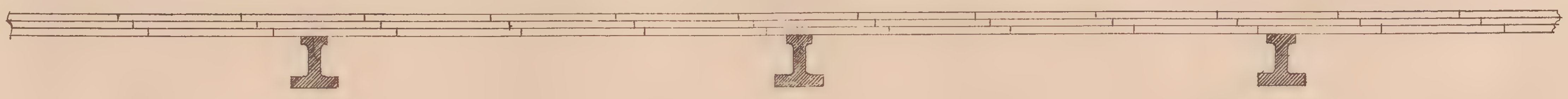
(6) FIRE-PROOF FLOOR, Section of Fig.5.

A
B
C
BATTEN 1½ IN. SQUARE
E
WROT IRON GIRDER
STONE
BRICK

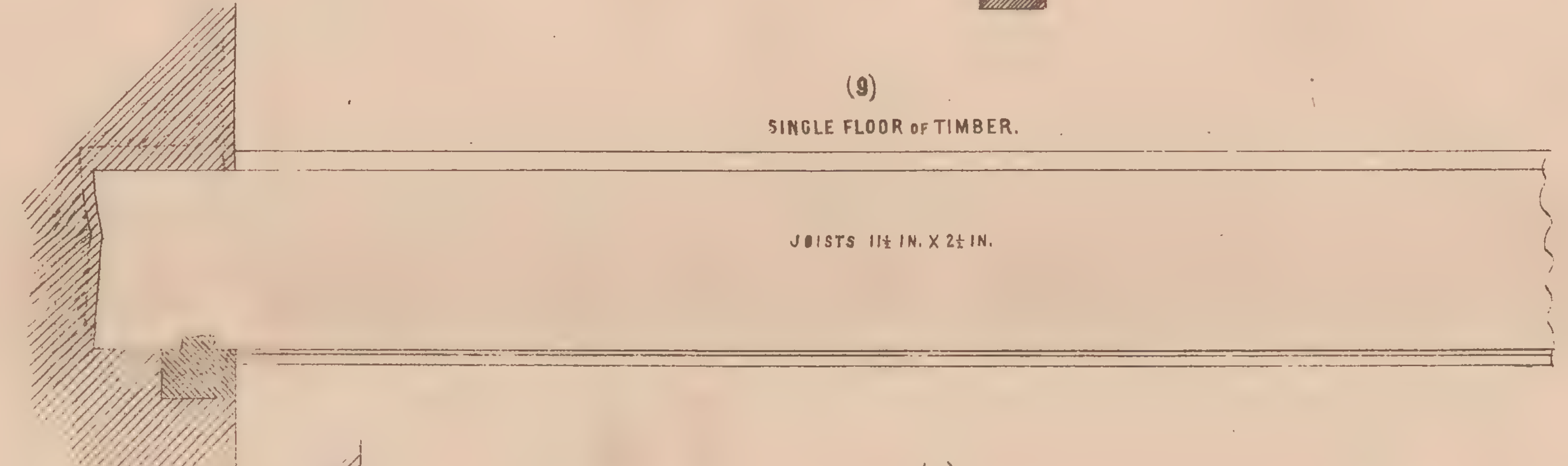


(7) FIRE-PROOF FLOOR, With Brick Arches.

FLOOR BOARDS.
CONCRETE
BRICK
CONCRETE
BRICK
CONCRETE
BRICK
CONCRETE
CAST-IRON BEAM

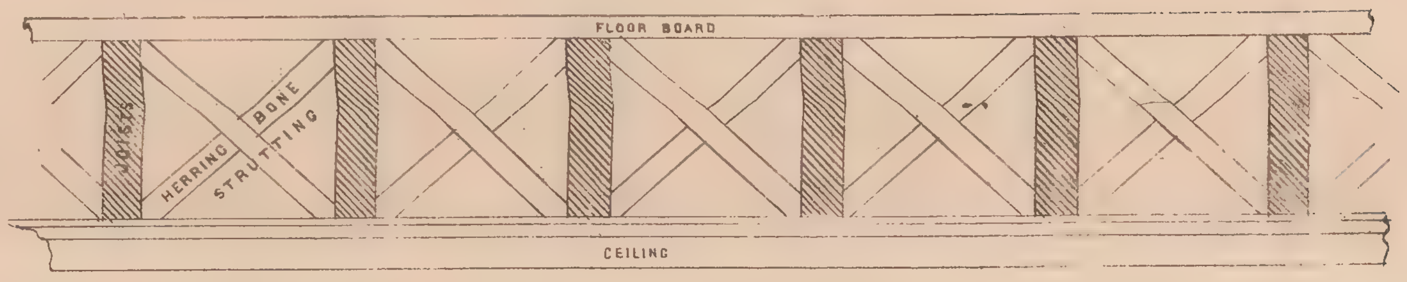


(8) FLAT TERRACE ON IRON JOISTS.



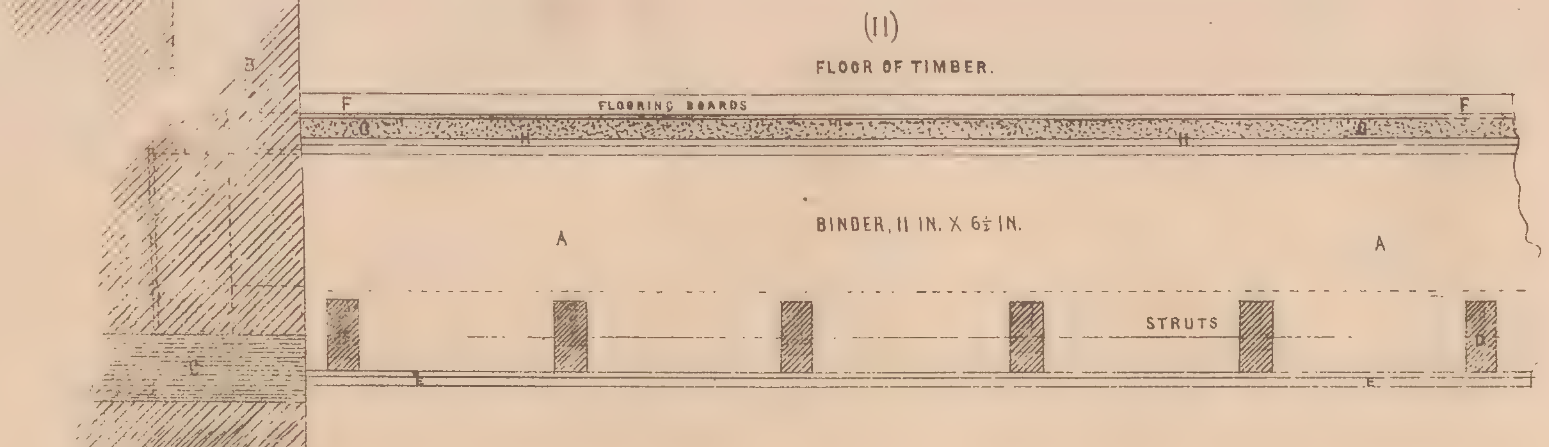
(9) SINGLE FLOOR of TIMBER.

JOISTS 11½ IN. X 2½ IN.



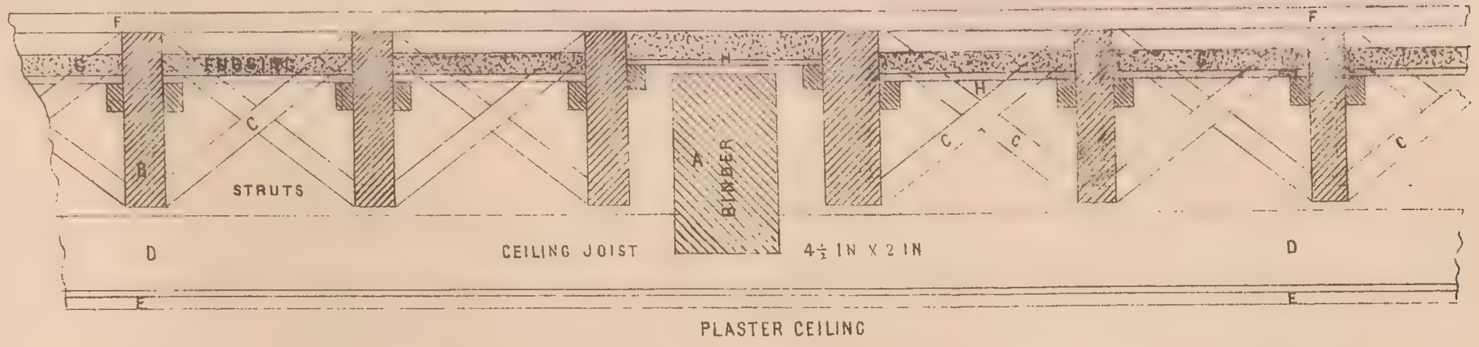
(10) SECTION OF FLOOR in Fig. Nº 9.

FLOOR BOARD
JOISTS
HERRING BONE STRUTTING
CEILING



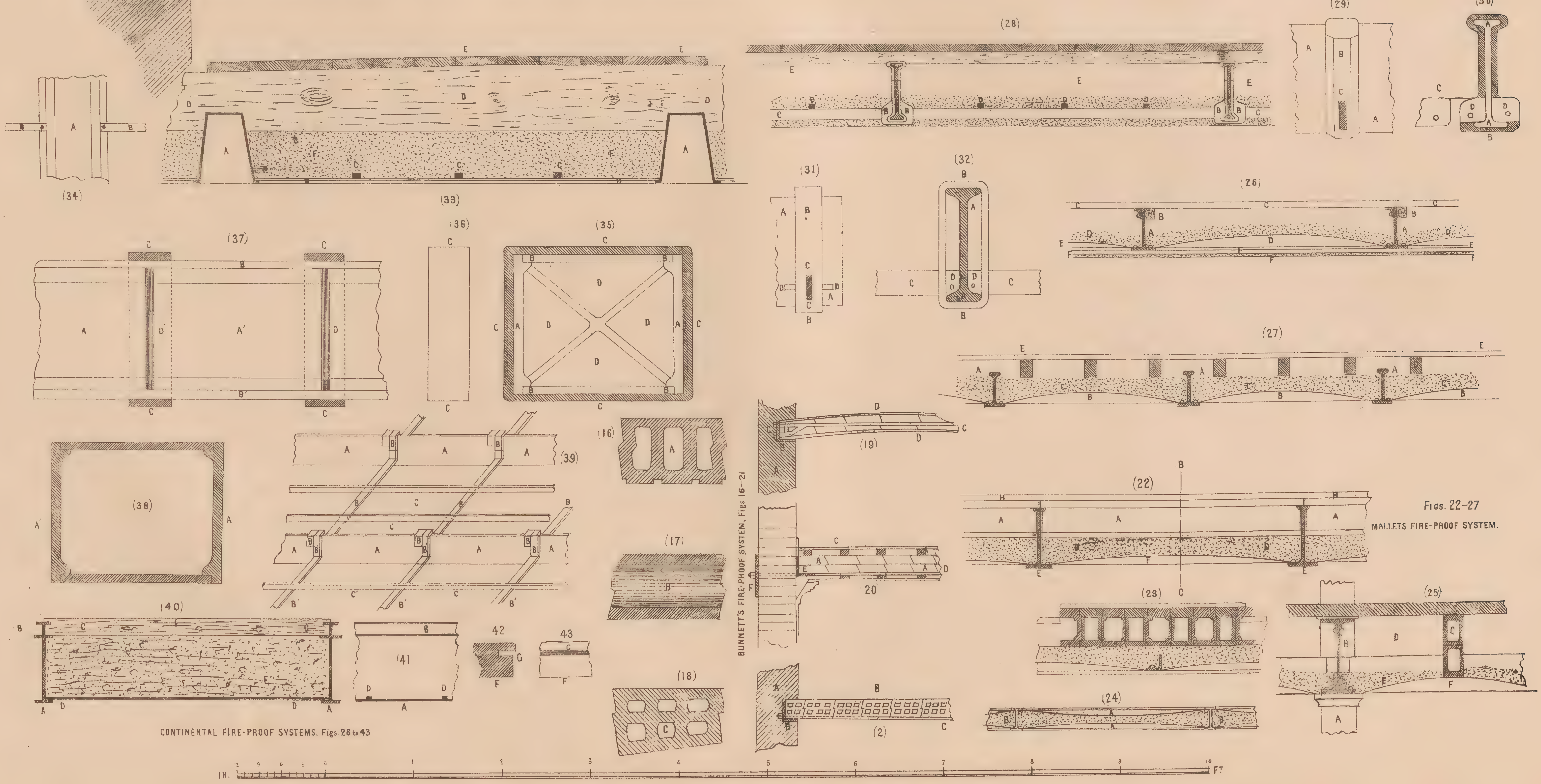
(11) FLOOR OF TIMBER.

B
F
FLOORING BOARDS
D
F
A
BINDER, 11 IN. X 6½ IN.
A
STRUTS



(12) CROSS SECTION of Fig. 11.

F
F
EMBERS
H
B
C
STRUTS
A
BINDER
D
CEILING JOIST
4½ IN X 2 IN
D
E
PLASTER CEILING



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A
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G
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IN.
FT

BUNNETT'S FIRE-PROOF SYSTEM, Figs. 16–21

Figs. 22–27 MALLETS FIRE-PROOF SYSTEM.

CONTINENTAL FIRE-PROOF SYSTEMS, Figs. 28 to 43

SCALE FOR FIGS. 1 to 12.

A. FULLARTON & CO. LONDON AND EDINBURGH.

WROUGHT IRON GIRDER WORK.

Half Elevation of Longitudinal Girder
Scale ¾" = 1 Foot

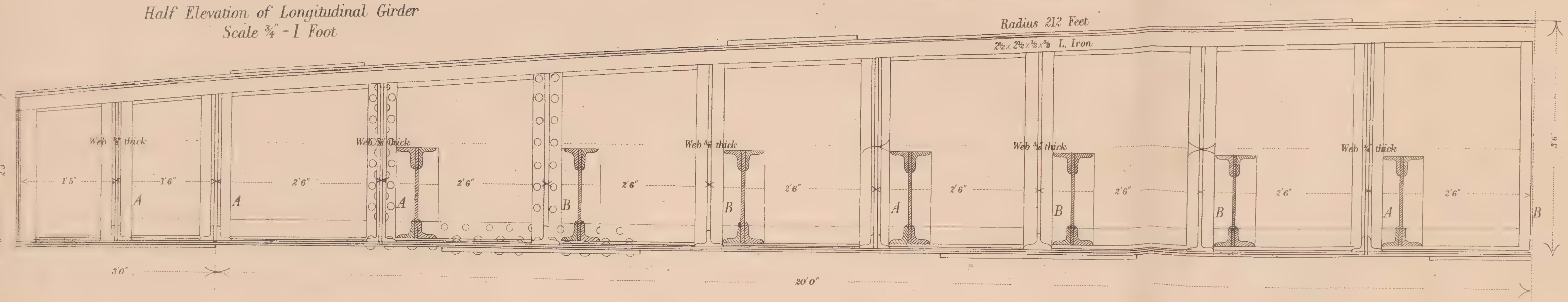

Radius 212 Feet
2½ × 2½ × ½ × ⅜ L. Iron
Web ⅜ thick
Web ⅜ thick
Web ⅜ thick
Web ⅜ thick
Web ⅜ thick
A
A
A
B
B
A
B
B
A
B
1'5"
1'6"
2'6"
2'6"
2'6"
2'6"
2'6"
2'6"
2'6"
2'6"
3'6"
3'0"
20'0"

Fig. A. Nº 1.

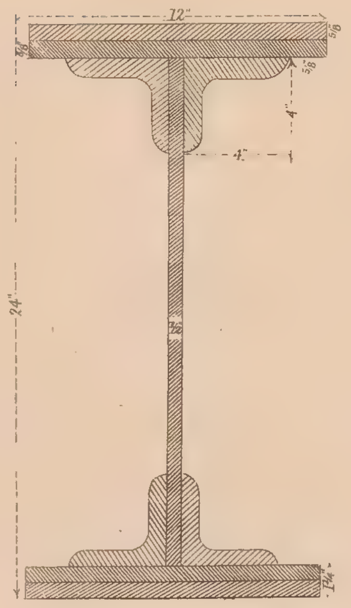


Fig. A. Nº 2.

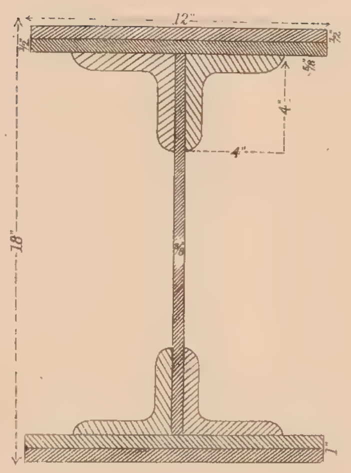
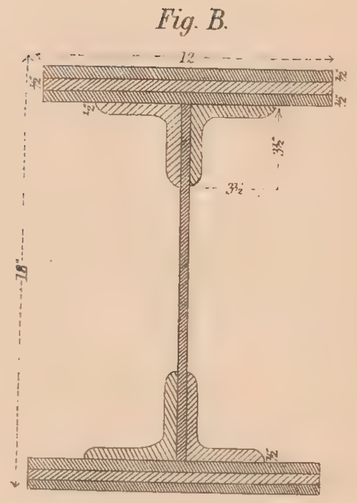
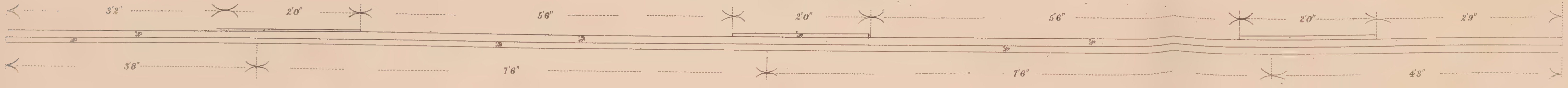


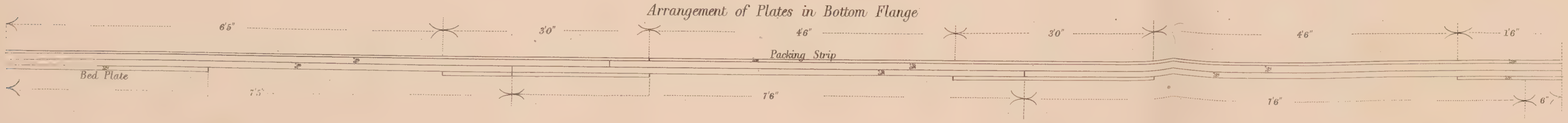
Fig. B.



Arrangement of Plates in Top Flange


5'2"
2'0"
5'6"
2'0"
5'6"
2'0"
2'9"
3'6"
7'6"
7'6"
4'3"

Arrangement of Plates in Bottom Flange


6'5"
3'0"
4'6"
3'0"
4'6"
1'6"
Packing Strip
Bed Plate
7'5"
7'6"
7'6"
6"

Scale for Figs. A to G. 1½" = 1 Foot

Fig. C.

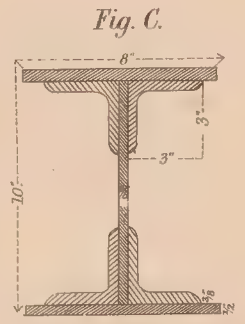


Fig. D.

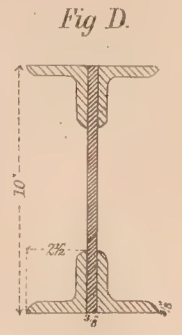
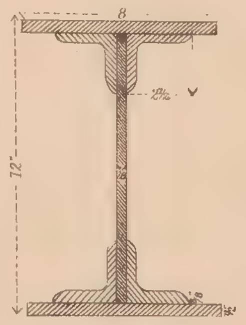


Fig. E.



Sectional Plan of Bottom Angle Irons and Part Plan of Top

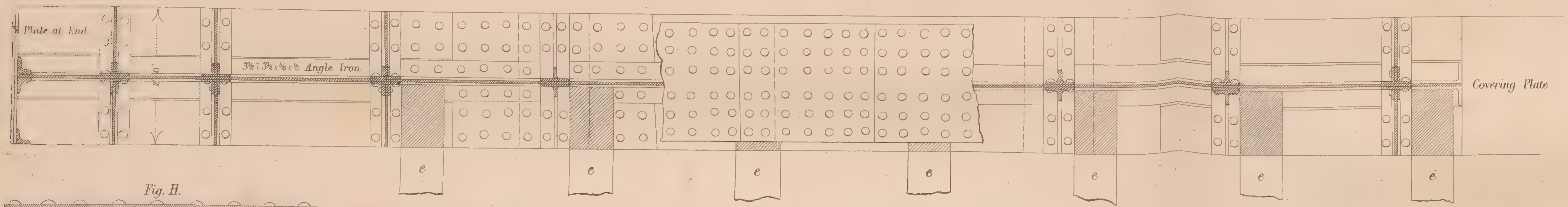

⅜ Plate at End
3½ × 3½ × ½ × ½ Angle Iron
Covering Plate
e
e
e
e
e
e
e

Fig. F.

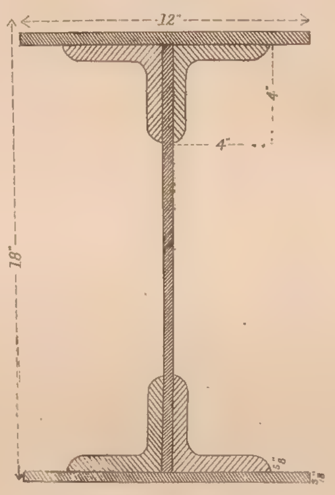
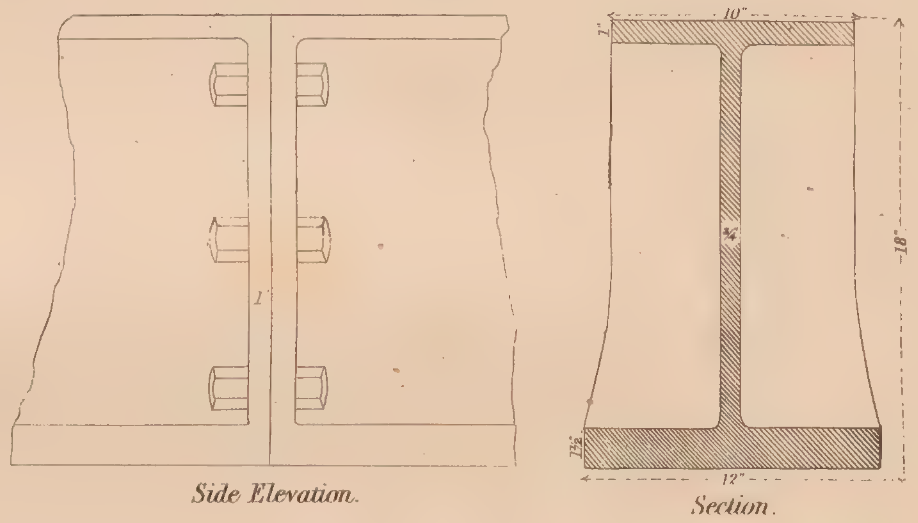


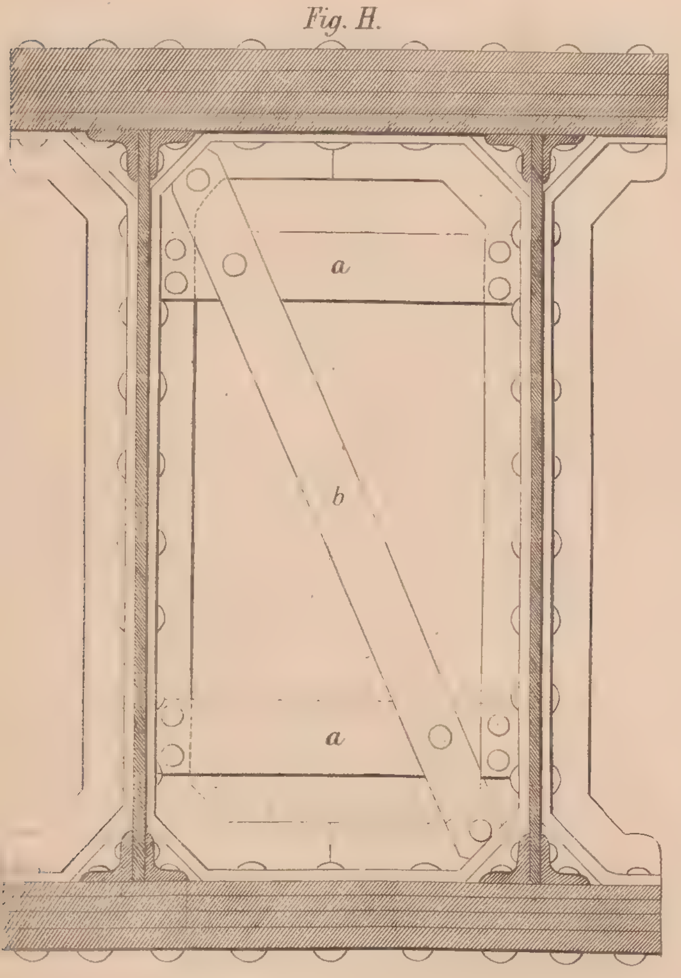
Fig. G.



Side Elevation.

Section.

Fig. H.

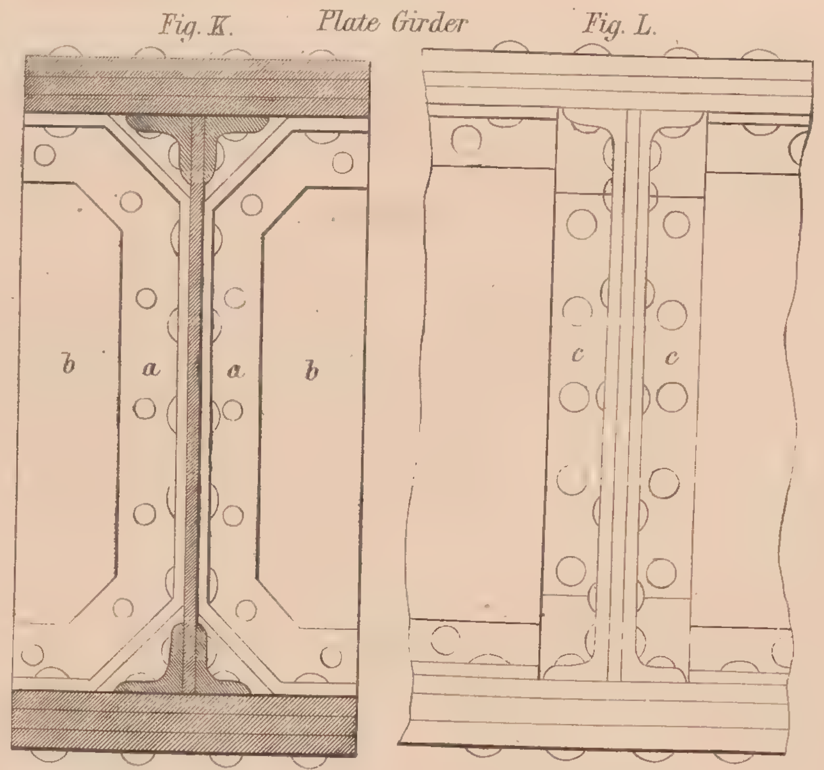


Transverse Section of Box Girder.

Plate Girder

Fig. K.

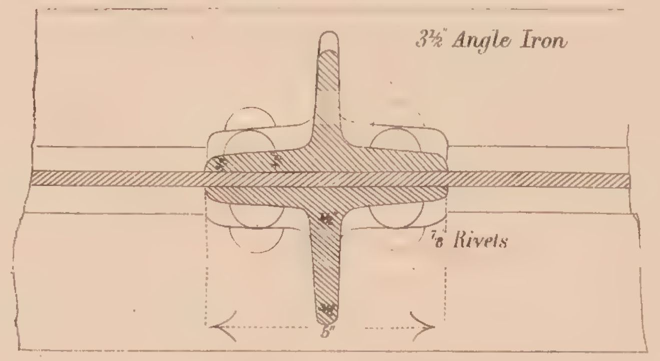
Fig. L.



Transverse Section

Side Elevation

Section through C.C. (Scale 3" = 1 Foot)


3½ Angle Iron
⅞ Rivets

Sectional Plan of Gusset A. (Scale 3" = 1 Foot)

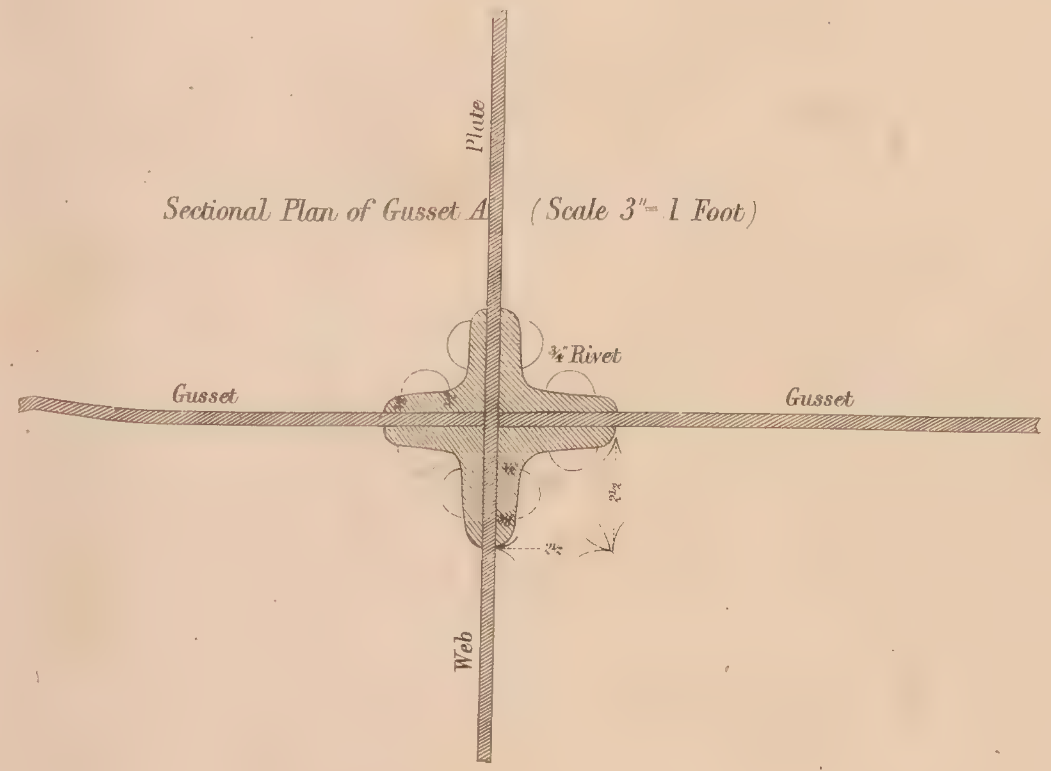


Plate
¾ Rivet
Gusset
Gusset
Web

Sectional Plan of T. Iron B. (Scale 3" = 1 Foot)

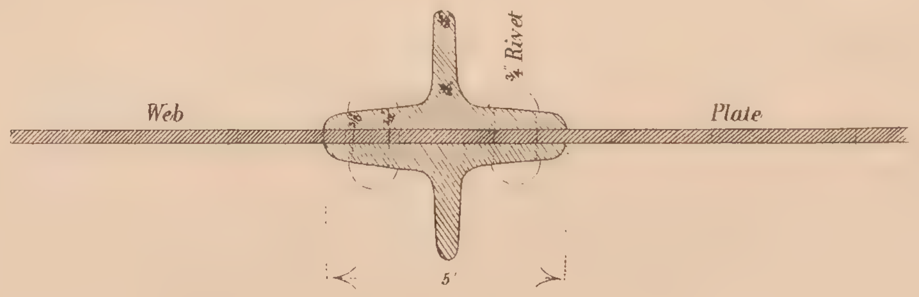
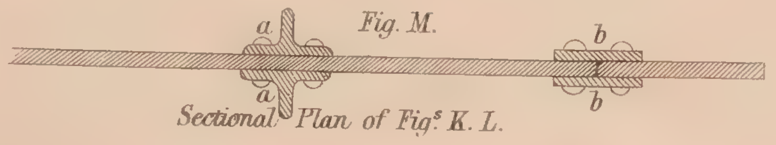
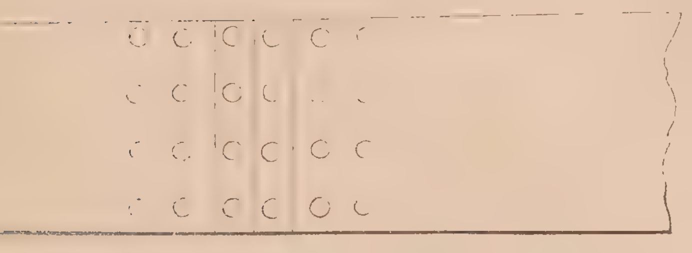

Web
Plate
¾ Rivet

Fig. M.



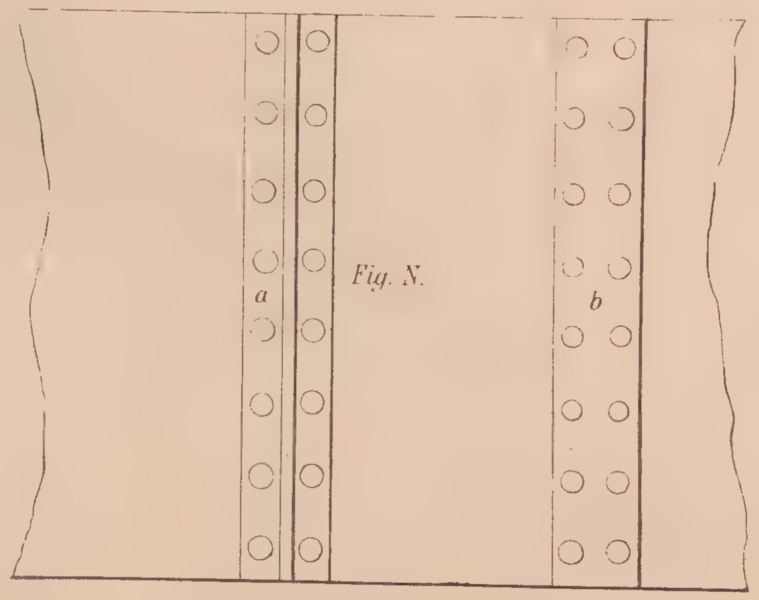
Sectional Plan of Figs. K. L.

Fig. I.



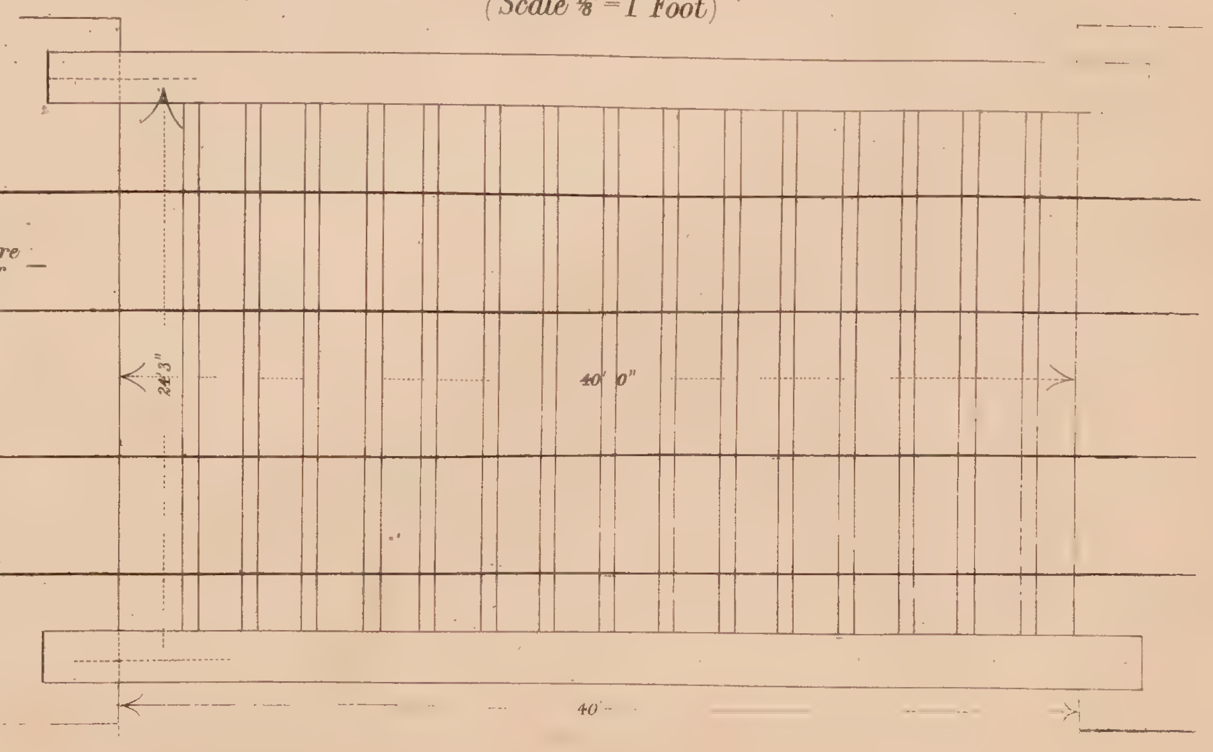
Plan of Covering Top Flange Junction of Fig. H.

Fig. N.

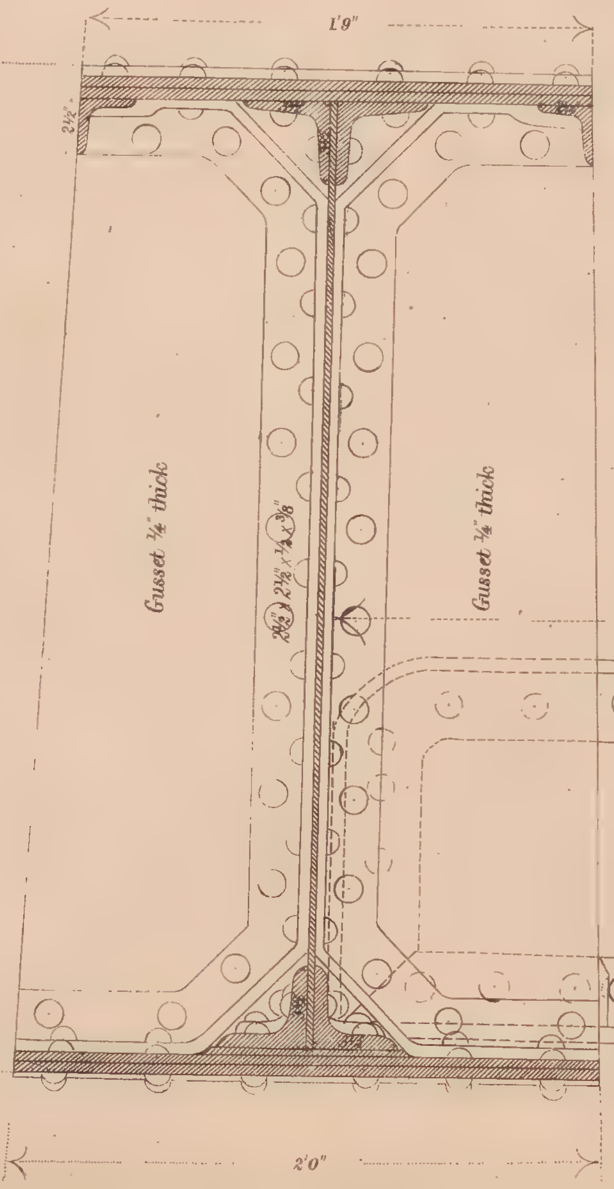


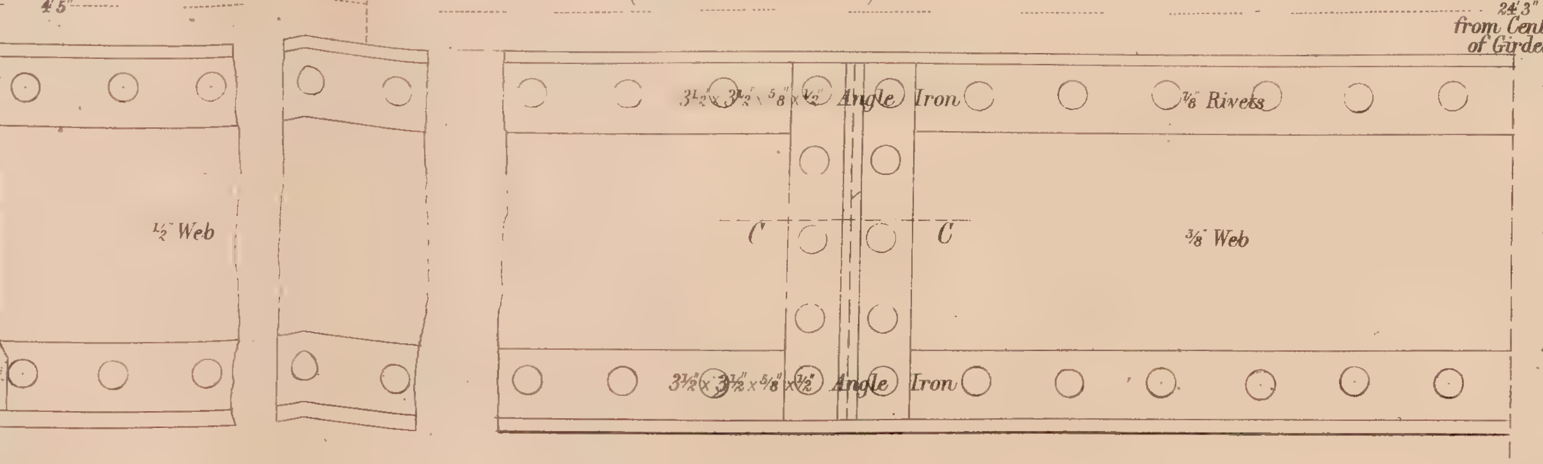
Elevation of Side Plates of Figs. K. L.

General Plan shewing Arrangement of Cross Girders
(Scale ⅛" = 1 Foot)



Cross Section of Girders, shewing one of the Girders
(Scale 1½" = 1 Foot)




1'9"
Gusset ¼ thick
Gusset ¼ thick
3'6"
4'5"
½ Web
24'3" from Centre of Girder
3½ × 3½ × ½ × ½ Angle Iron
⅞ Rivets
C
C
⅜ Web
3½ × 3½ × ½ × ½ Angle Iron
2'0"

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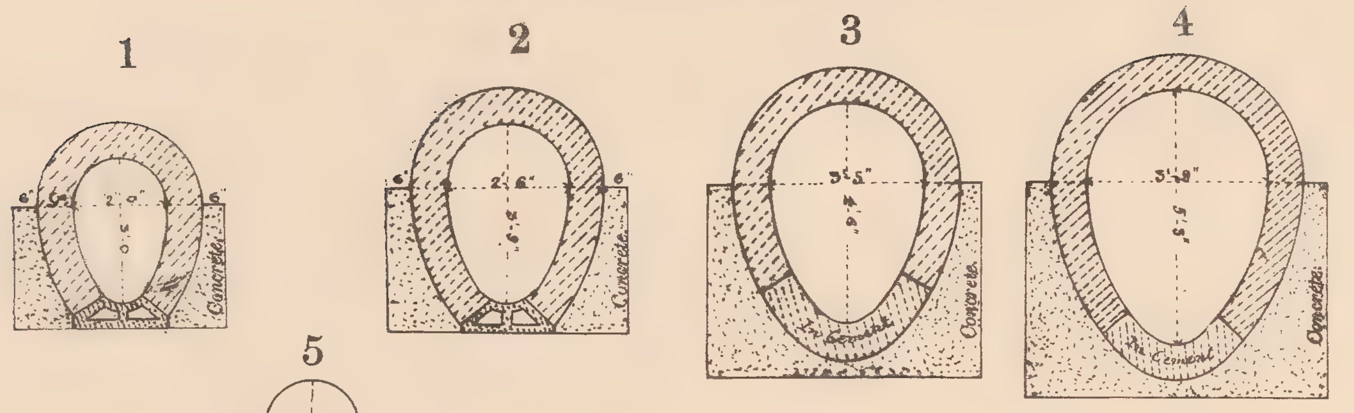
CROSS SECTIONS OF EGG-SHAPED BRANCH SEWERS.


1
2
3
4
Concrete
Concrete
Concrete
Concrete

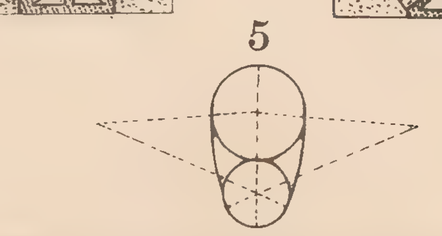
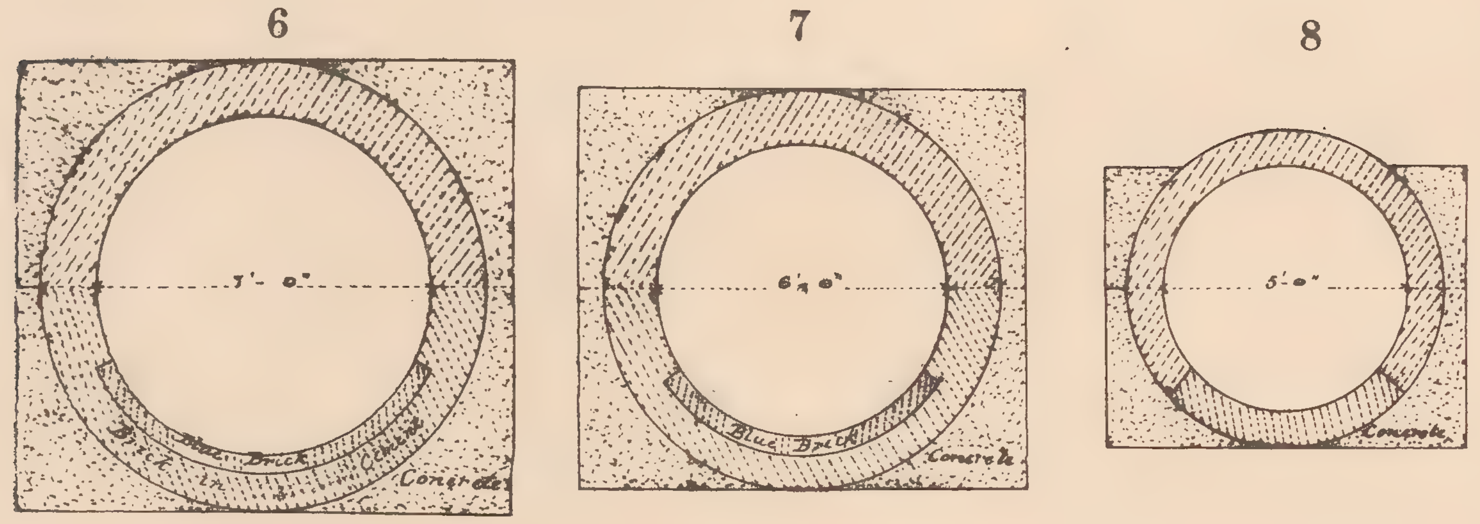
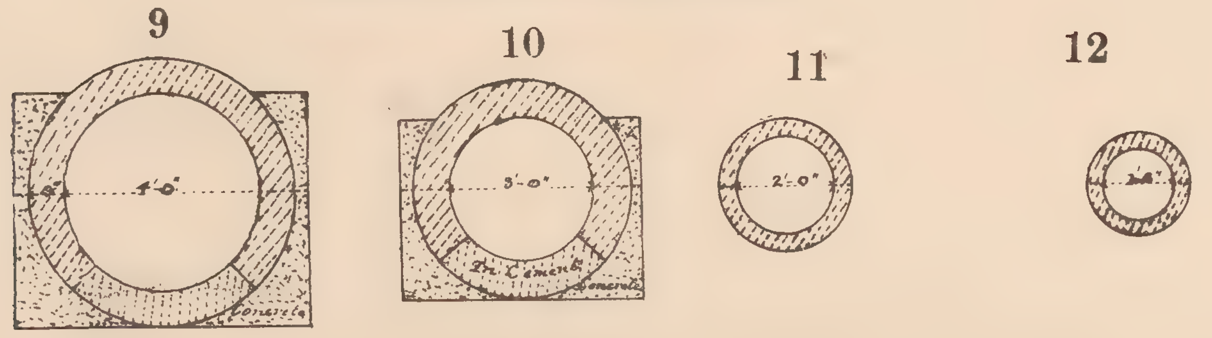


DIAGRAM OF CENTRES FOR FORMING EGG-SHAPED SECTIONS


6
7
8
7'-0"
6'-0"
5'-0"
Blue Brick
Concrete

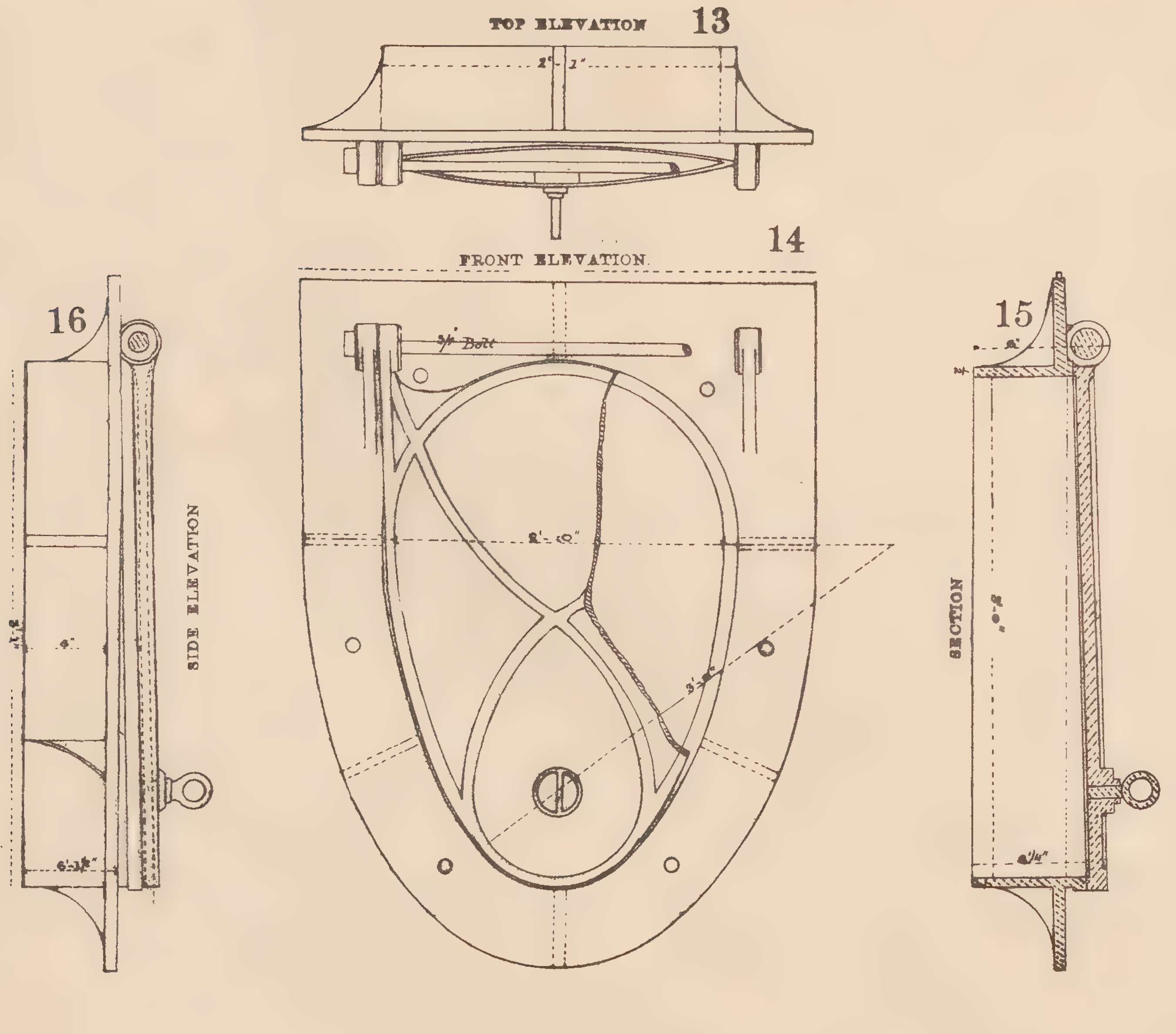
CROSS SECTIONS OF BARREL SEWERS.


9
10
11
12
4'-0"
3'-0"
2'-0"
in Cement
Concrete

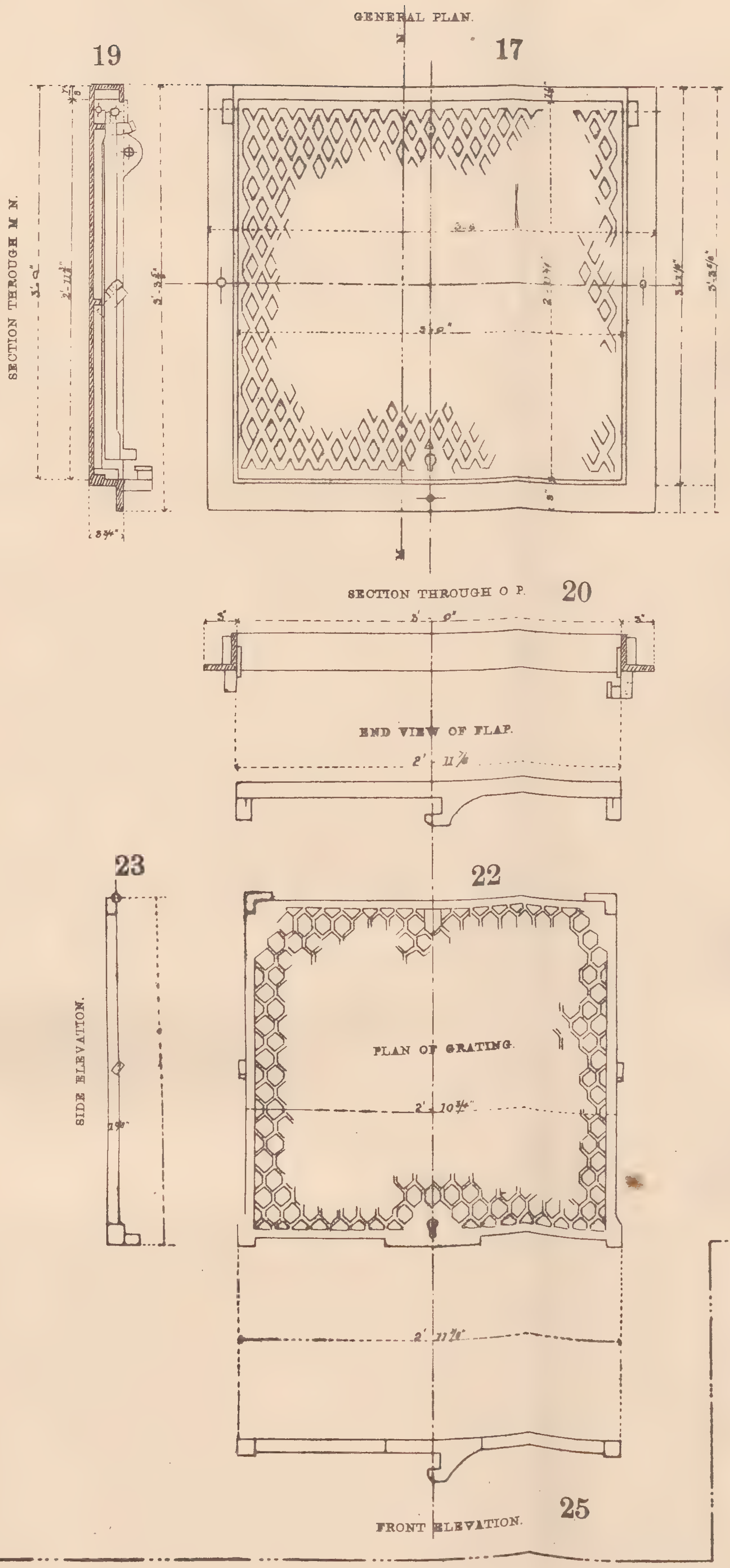
STREET DRAINAGE.

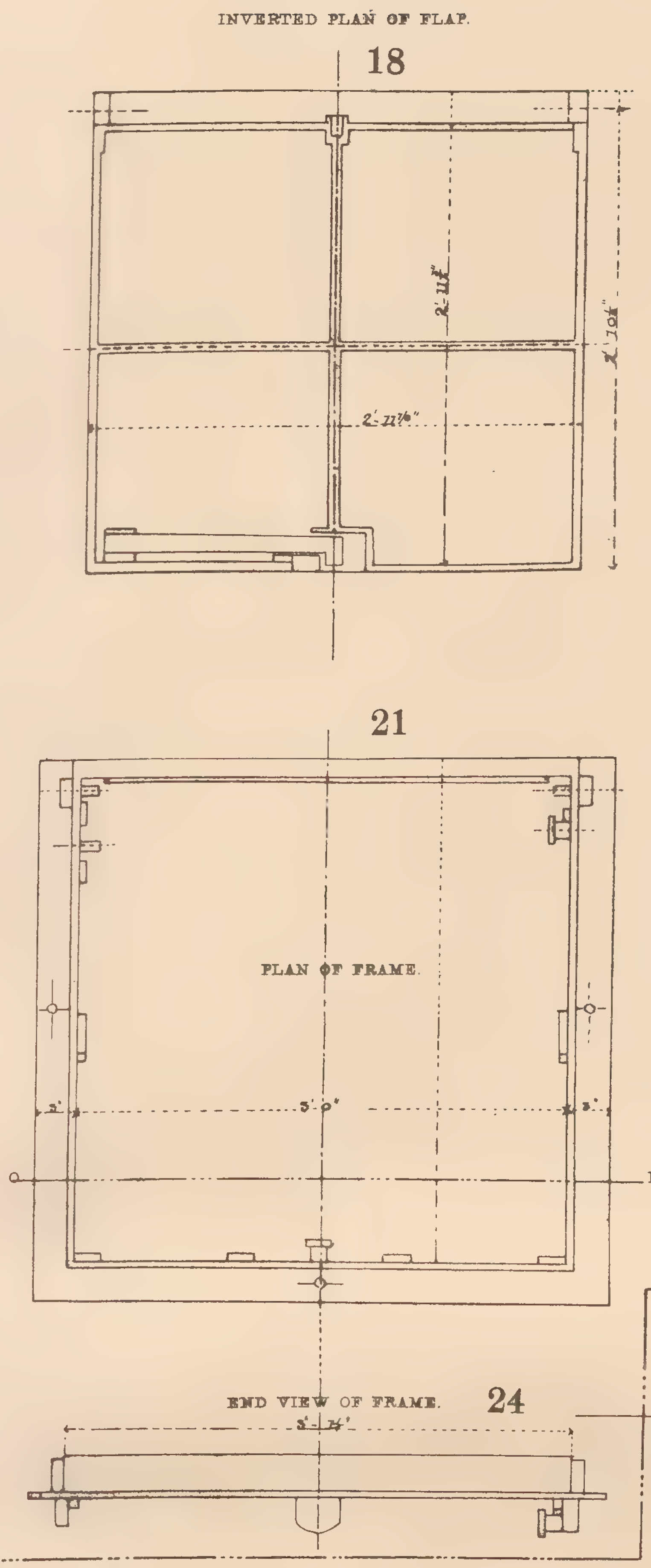
PLANS AND SECTIONS OF BARREL AND EGG-SHAPED SEWERS, &c.,
WITH DETAILS.

DETAILS OF IRON FLAP FOR JUNCTION.

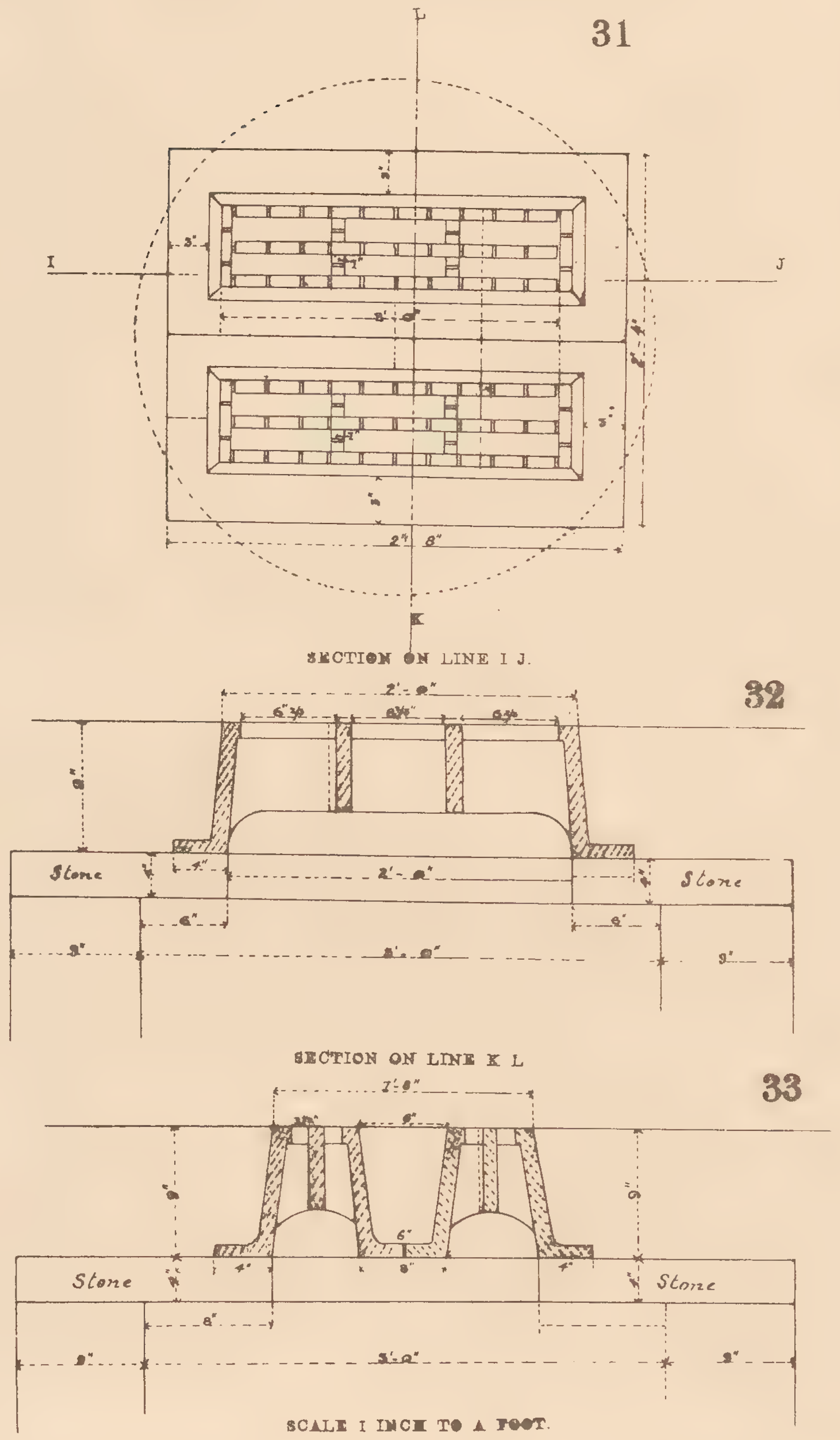

TOP ELEVATION
13
FRONT ELEVATION
14
15
16
SIDE ELEVATION
SECTION
¾" Bolt

DETAILS OF MAN HOLE OR SIDE ENTRANCE COVER.
SCALE 1 INCH TO A FOOT

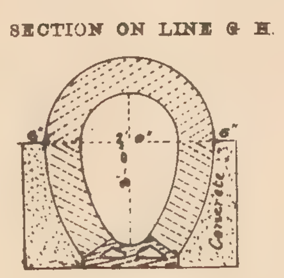

GENERAL PLAN.
17
19
SECTION THROUGH M N.
SECTION THROUGH O P.
20
END VIEW OF FLAP.
2' 11⅞"
22
23
SIDE ELEVATION.
PLAN OF GRATING.
2' 10¾"
FRONT ELEVATION.
25


INVERTED PLAN OF FLAP.
18
2' 11¼"
21
PLAN OF FRAME.
3' 0"
END VIEW OF FRAME.
24

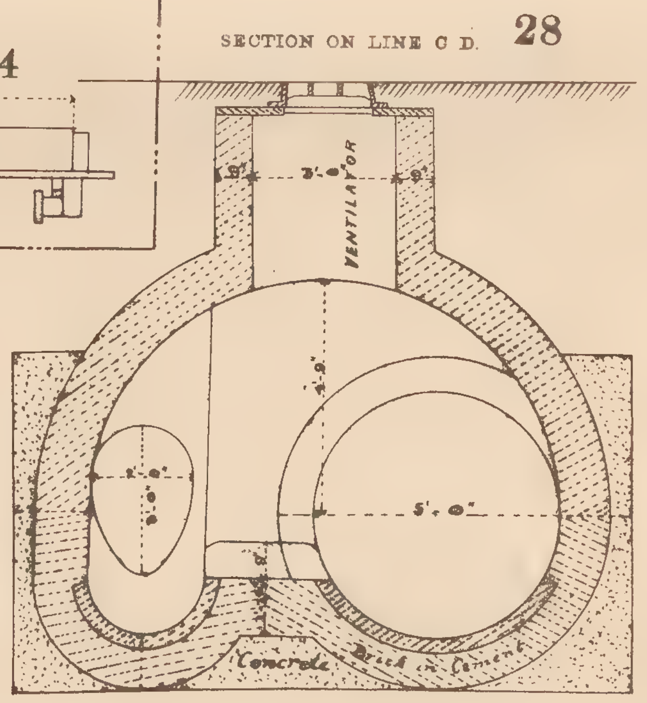
DETAILS OF GRATING FOR VENTILATORS.


31
I
J
K
SECTION ON LINE I J.
32
2' 0"
Stone
Stone
SECTION ON LINE K L.
33
Stone
Stone

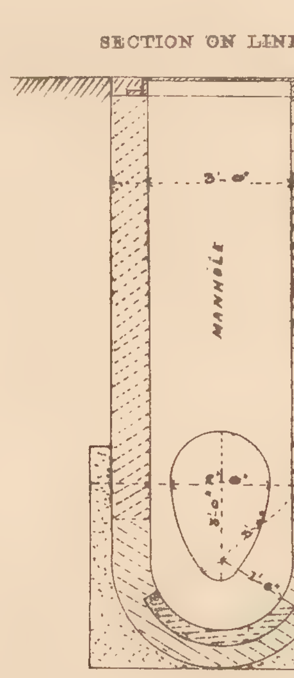
SCALE 1 INCH TO A FOOT.


30
Concrete

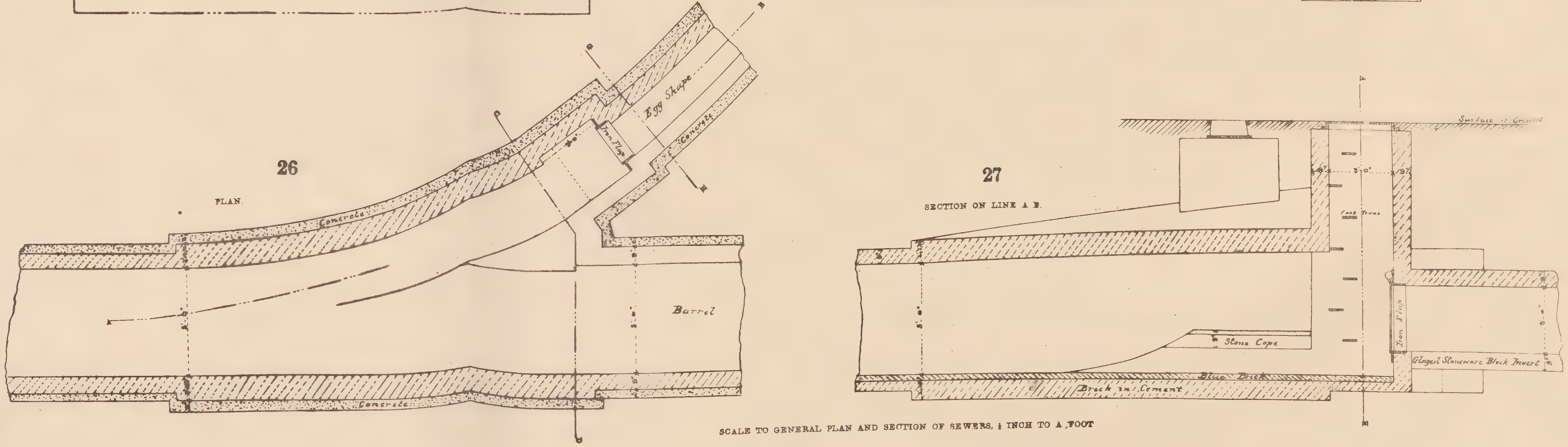
SECTION ON LINE G H.


28
VENTILATOR
3' 0"
5' 0"
Concrete
Brick in Cement

SECTION ON LINE C D.


29
3' 0"
MANHOLE
Concrete

SECTION ON LINE E F.


26
PLAN.
Concrete
Egg Shape
Concrete
Iron Flap
Barrel
Concrete
27
SECTION ON LINE A B.
Surface of Ground
Foot Irons
Stone Cope
Blue Brick
Brick in Cement
Iron Flap
Glazed Stoneware Block Invert

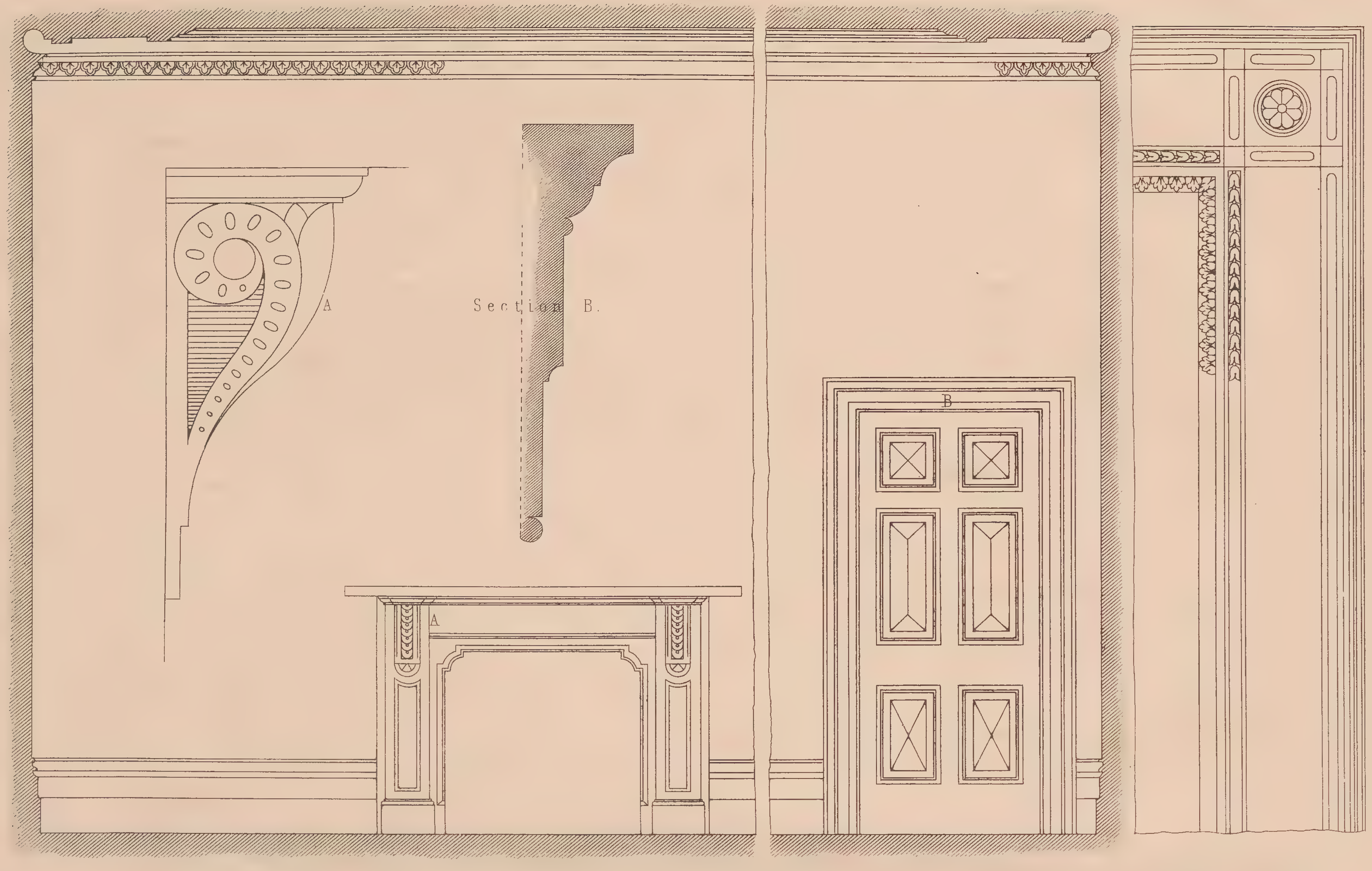
SCALE TO GENERAL PLAN AND SECTION OF SEWERS, ¼ INCH TO A FOOT

DESIGNS FOR INTERIORS,

IN DIFFERENT STYLES.

Italian Interior.

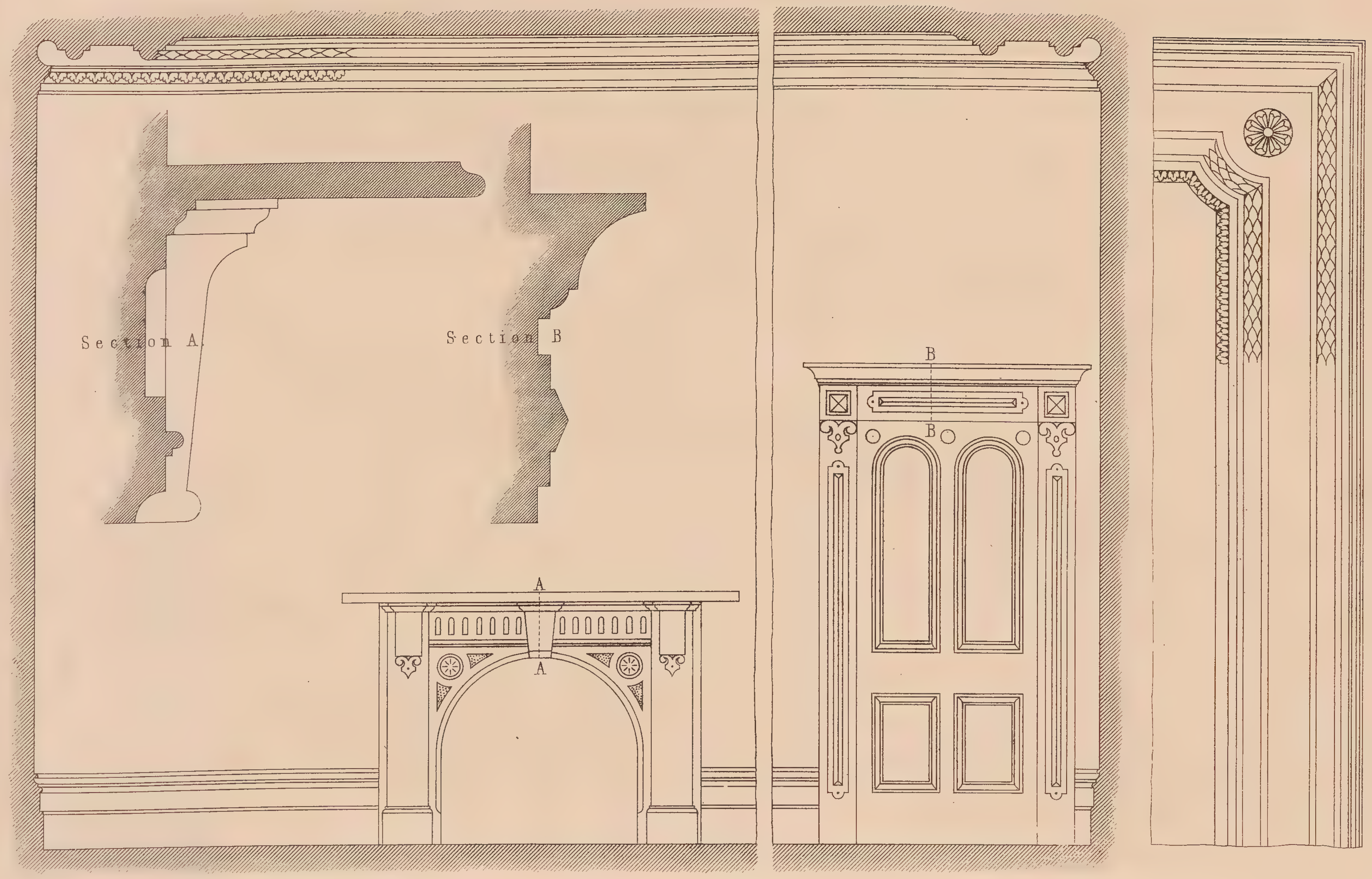
½ Inch Scale


A
Section B.
A
B

Elevation of Walls. Plan of Ceiling.

Italian Interior.

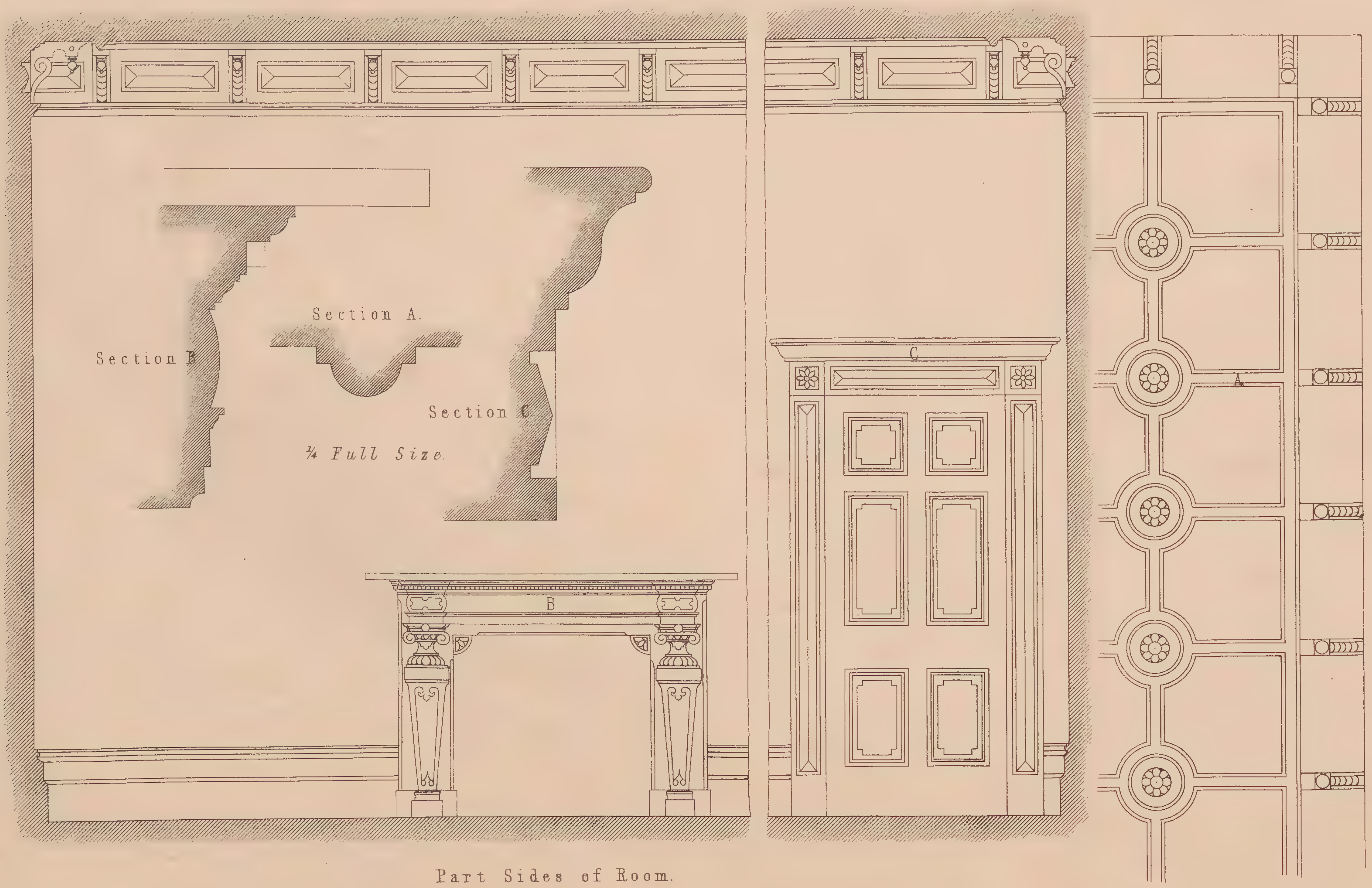
½ Inch Scale


Section A.
Section B
B
B
A
A

Elevation of Walls. Plan of Ceiling.

Elizabethan Interior.

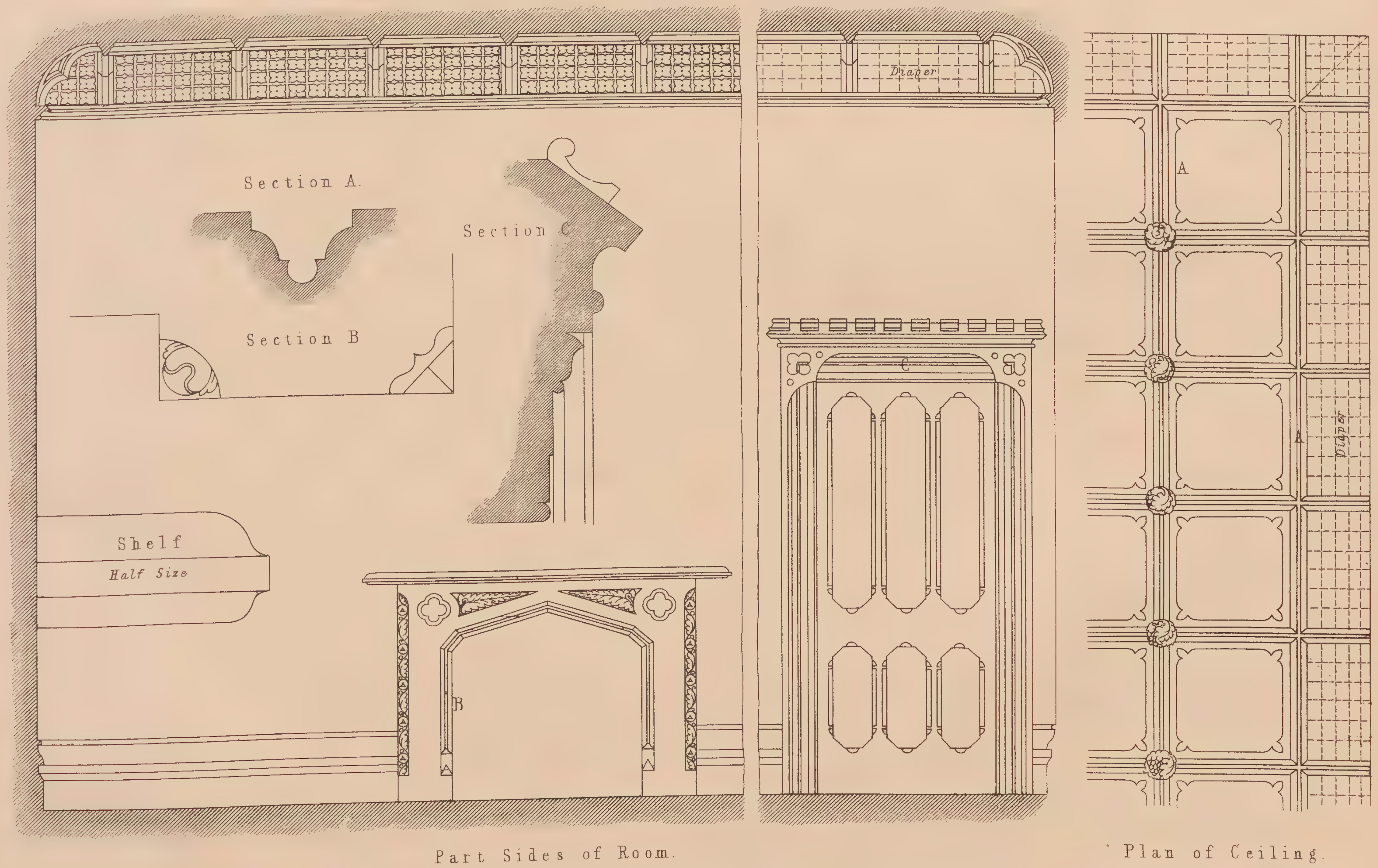
½ Inch Scale


Section B
Section A.
Section C
¾ Full Size
C
B
A

Part Sides of Room. Plan of Ceiling

Gothic Interior.

½ Inch Scale

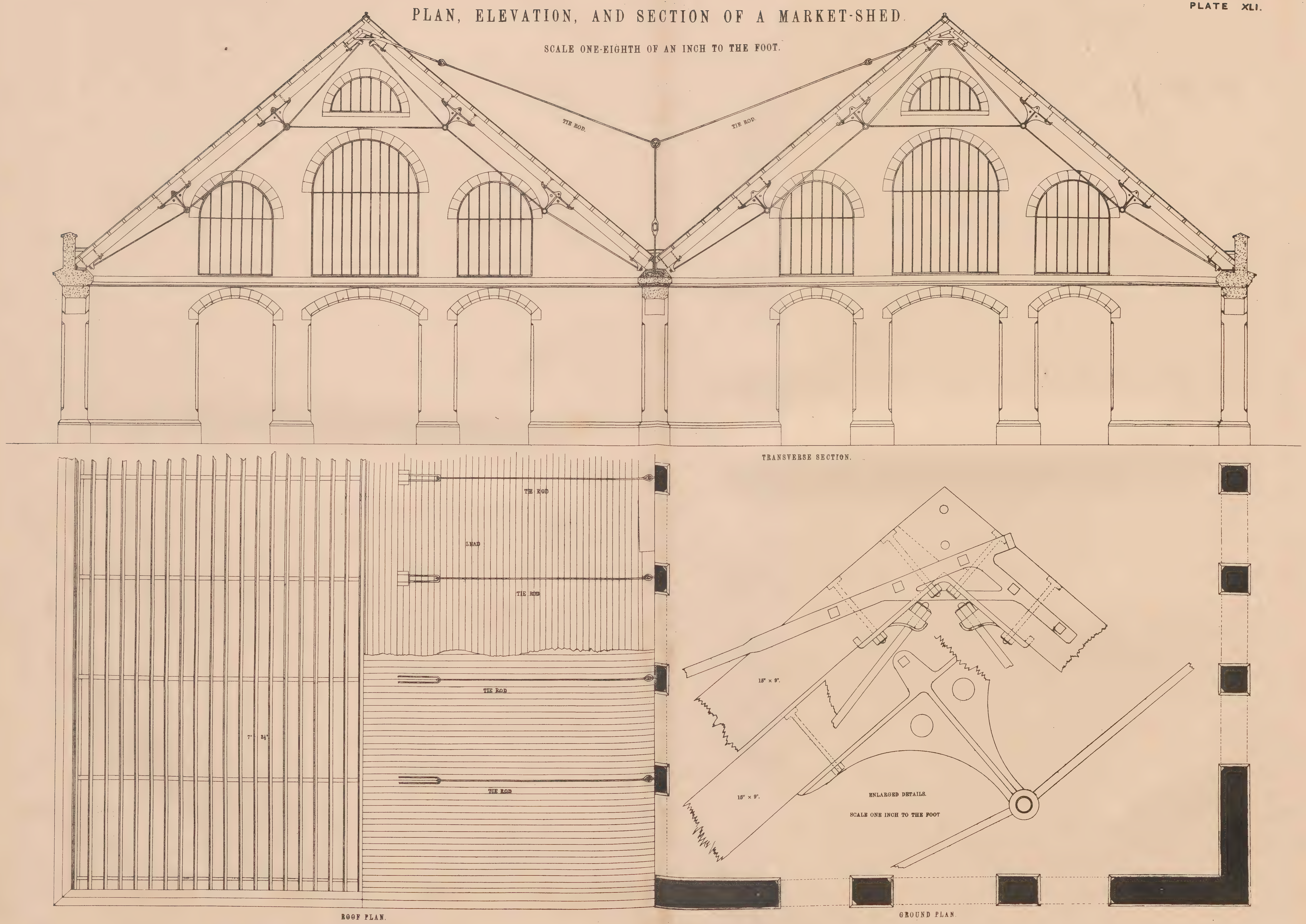

Diaper
Section A.
Section C
Section B
Shelf
Half Size
C
B
A
A
Diaper

Part Sides of Room. Plan of Ceiling.

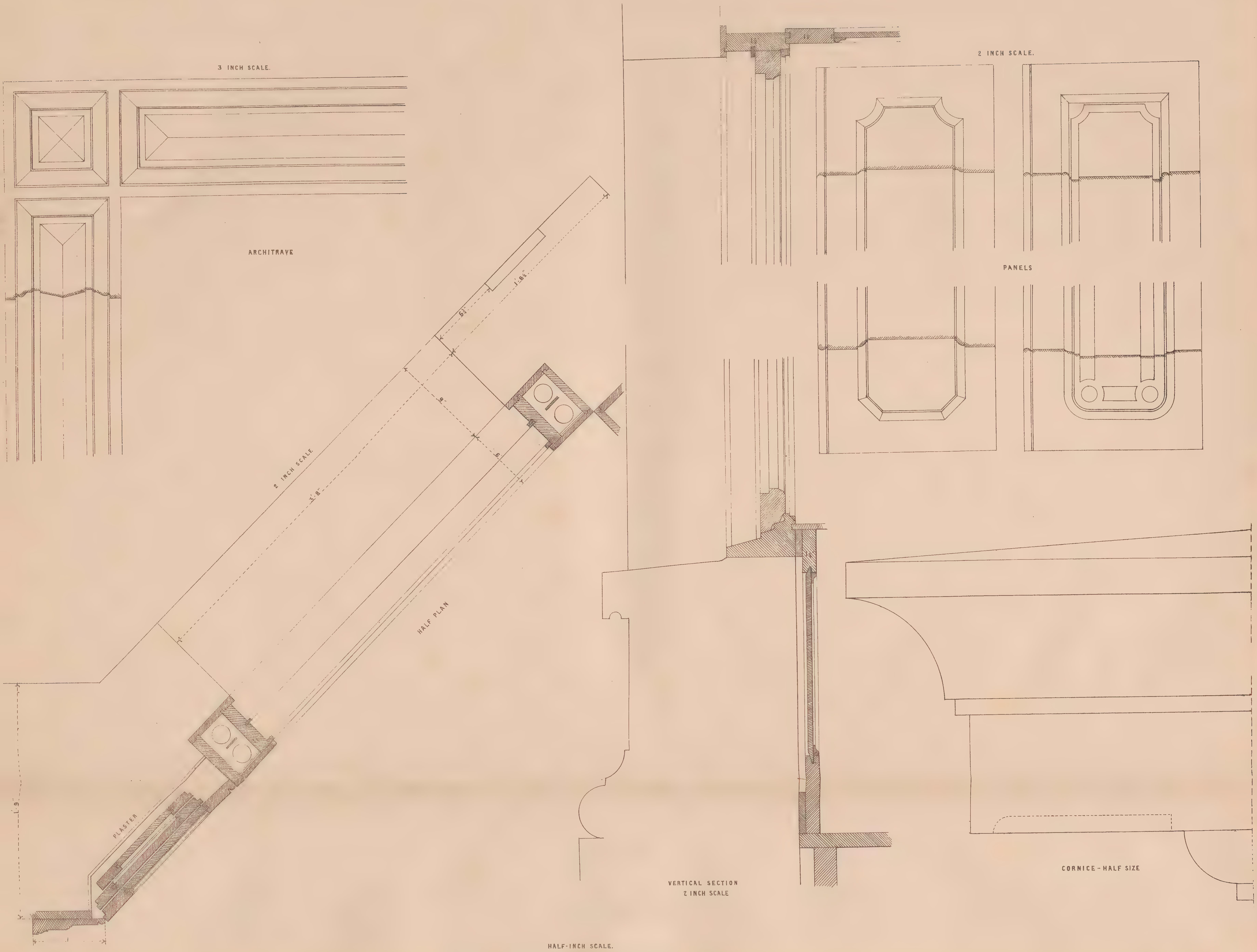
PLATE XLI.

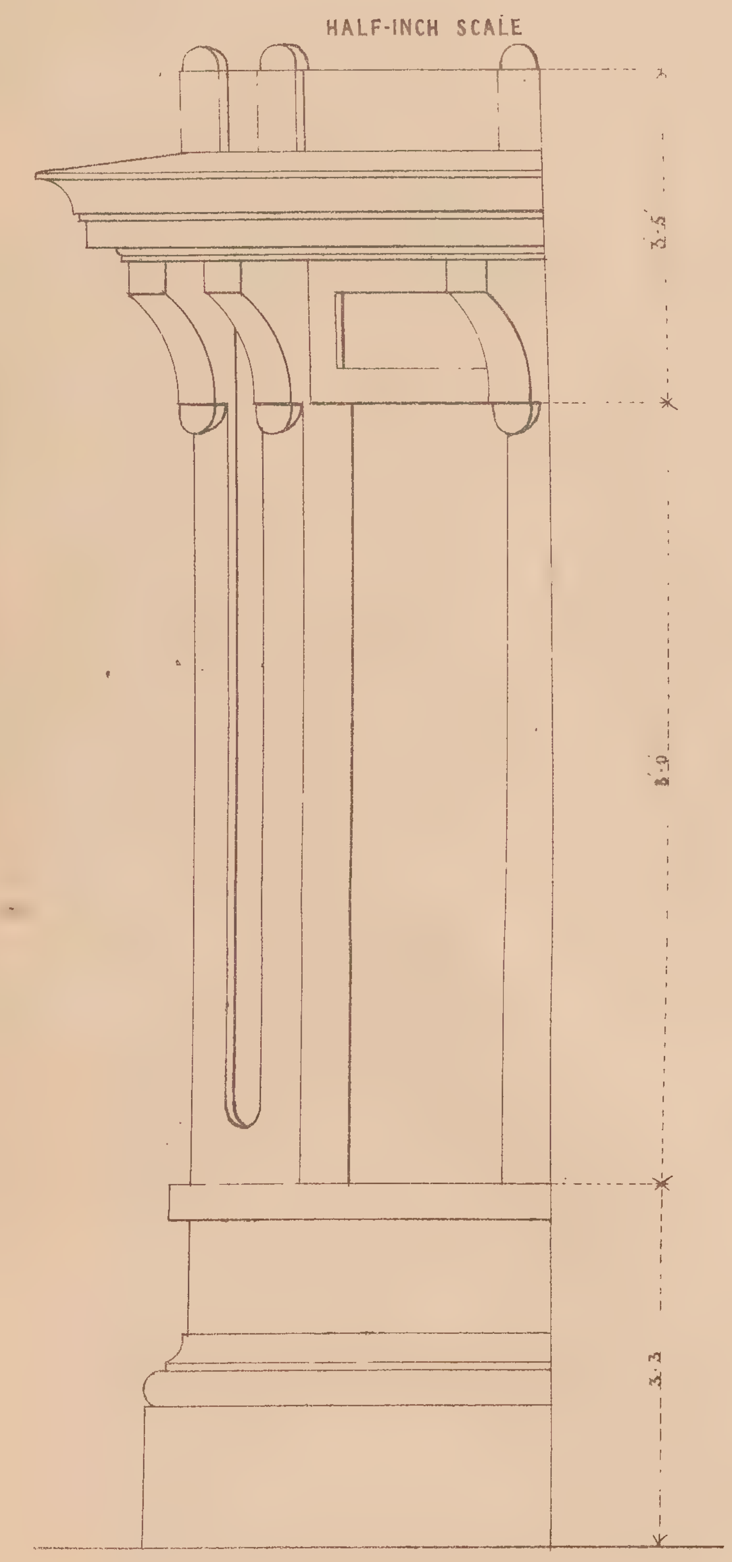
PLAN, ELEVATION, AND SECTION OF A MARKET-SHED.

SCALE ONE-EIGHTH OF AN INCH TO THE FOOT.

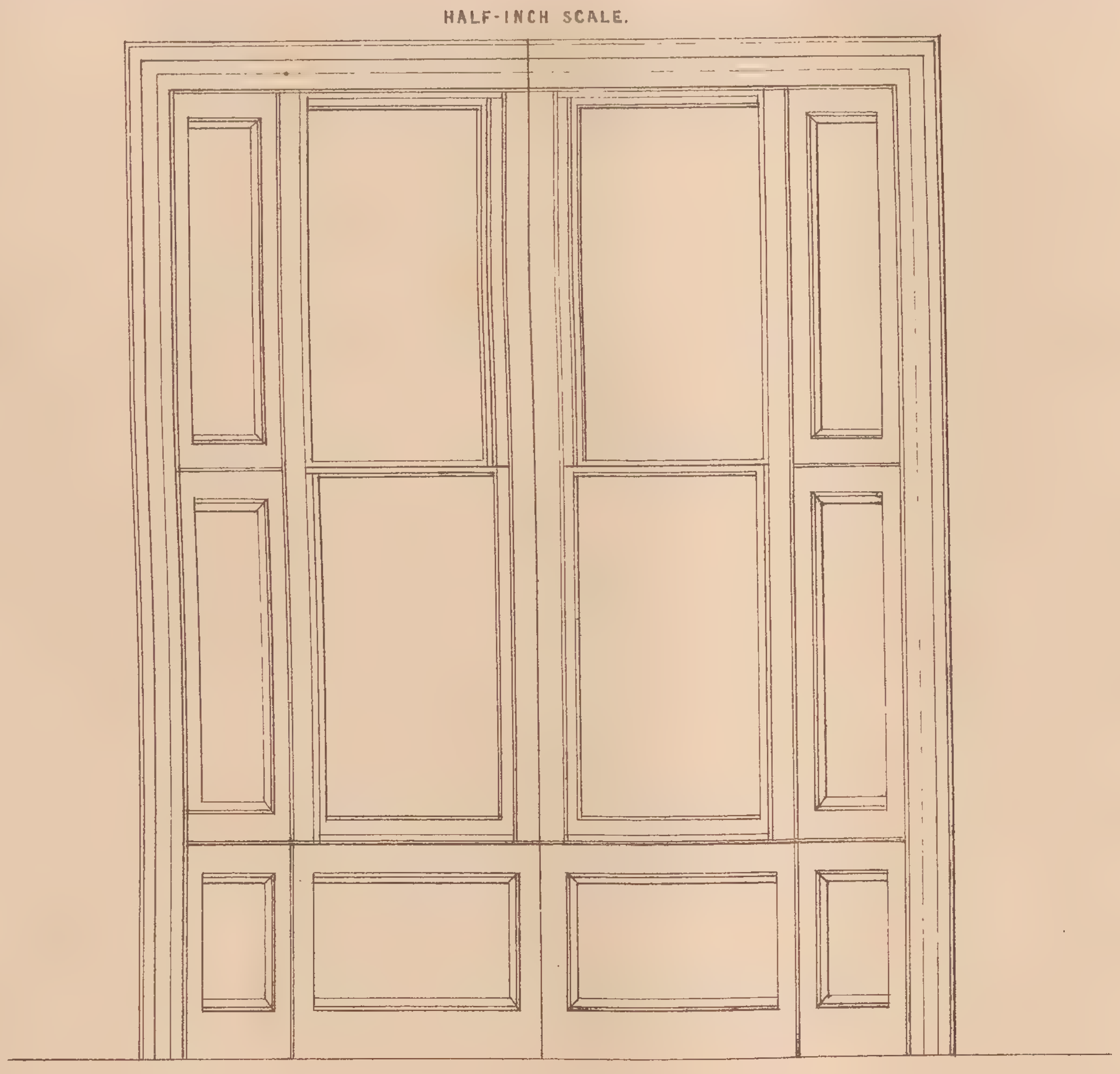

TIE ROD.
TIE ROD.
TRANSVERSE SECTION.
TIE ROD
LEAD
TIE ROD
TIE ROD
TIE ROD
7" 3¼"
ROOF PLAN.
15" × 9".
15" × 9".
ENLARGED DETAILS.
SCALE ONE INCH TO THE FOOT
GROUND PLAN.

DESIGN FOR A "V" WINDOW. STYLE, ANGLO-ITALIAN.

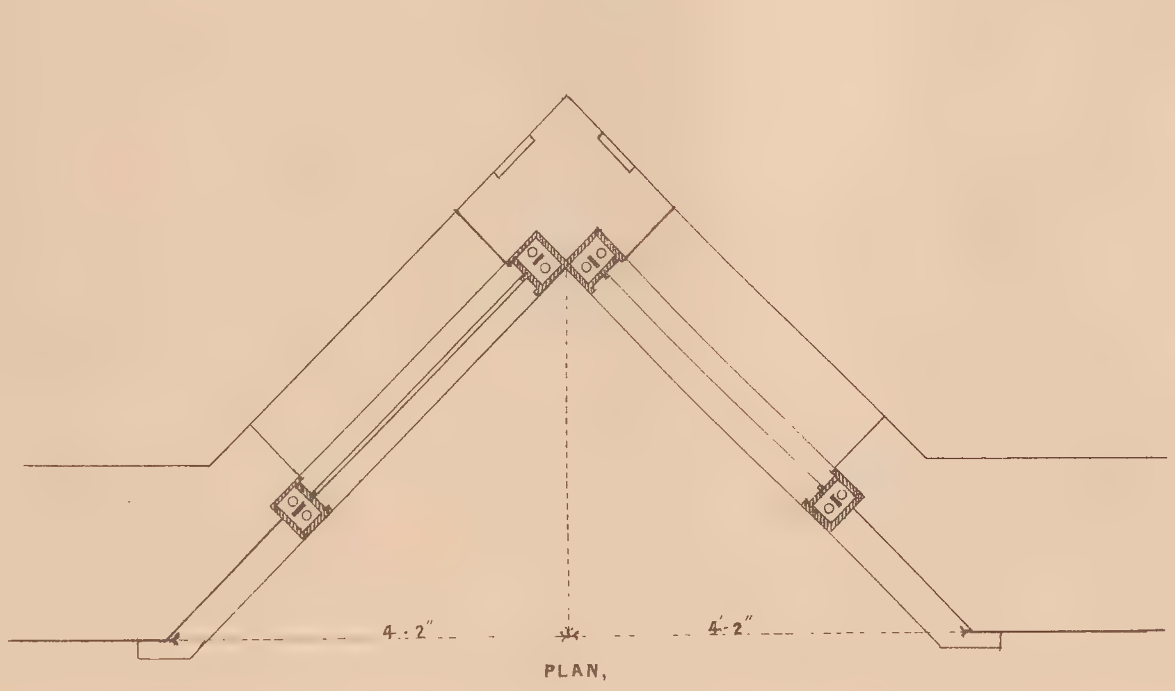

3 INCH SCALE.
ARCHITRAVE
2 INCH SCALE
HALF PLAN
PLASTER
1.8½
5½
6
6
3.8
1.9
2 INCH SCALE.
PANELS
VERTICAL SECTION
2 INCH SCALE
CORNICE - HALF SIZE


HALF-INCH SCALE
3.5
5.9
3.3

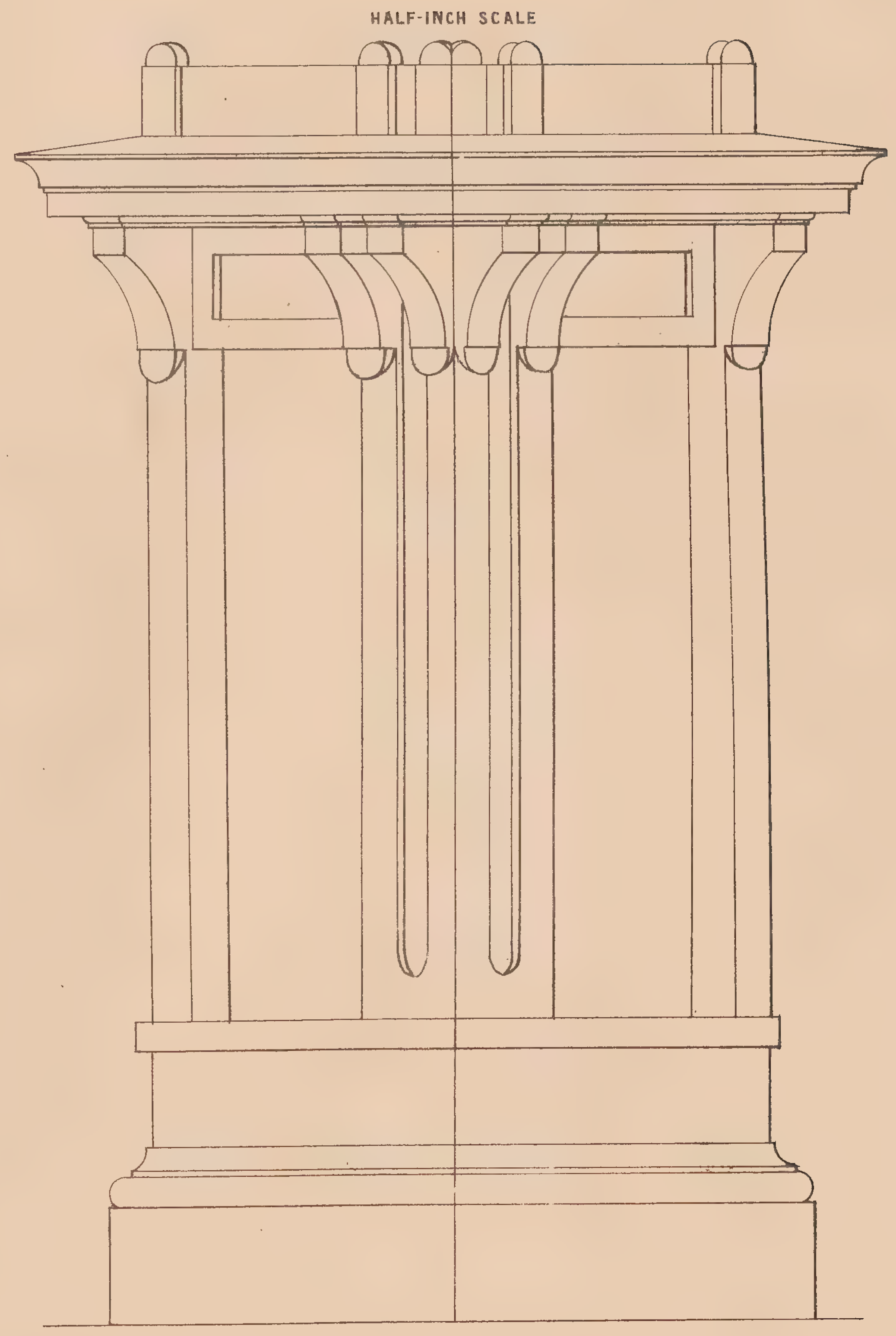
SIDE ELEVATION


HALF-INCH SCALE.

INTERIOR ELEVATION



PLAN,
HALF-INCH SCALE


HALF-INCH SCALE

FRONT ELEVATION

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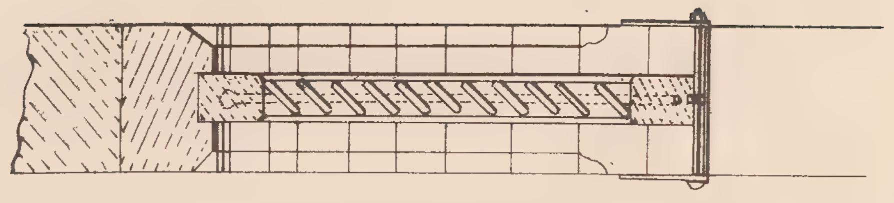
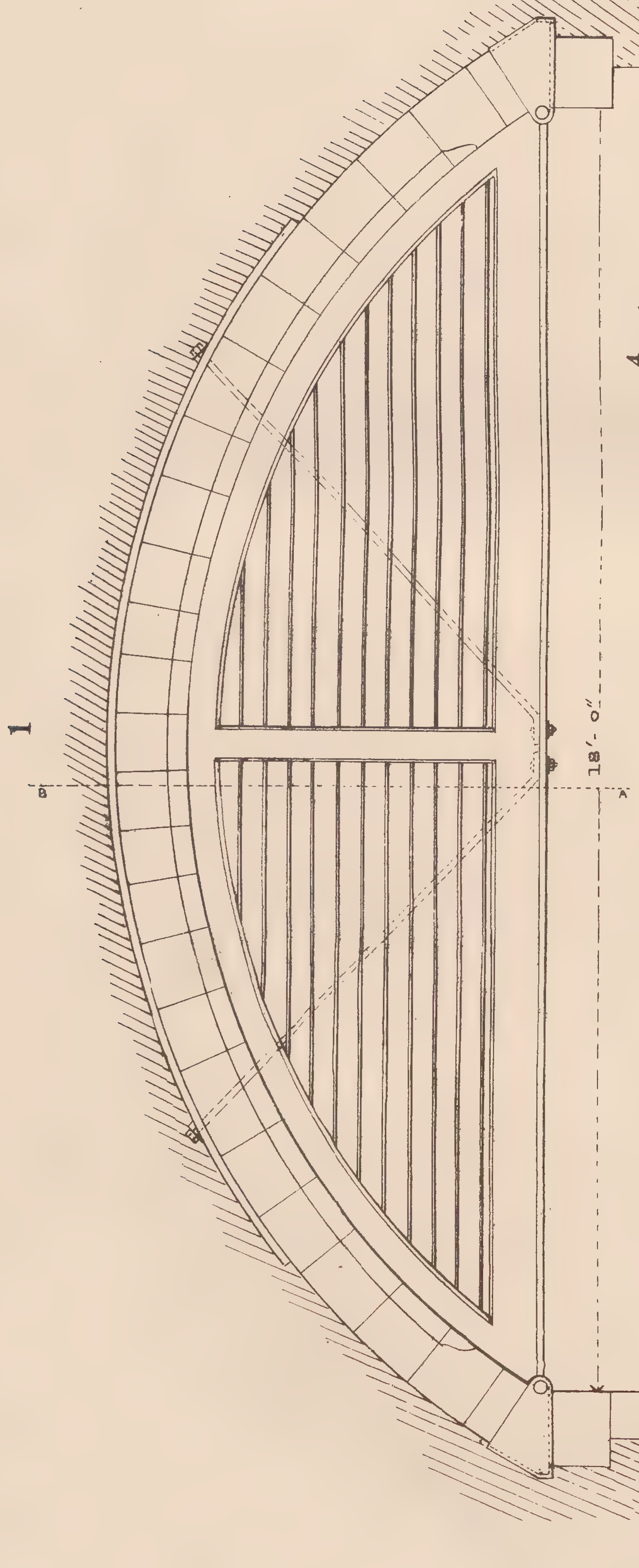
EXAMPLES OF TIMBER SHEDDING, ROOFS, AND LOUVRE BOARDING FOR ARCHWAYS.

PLATE XLIII

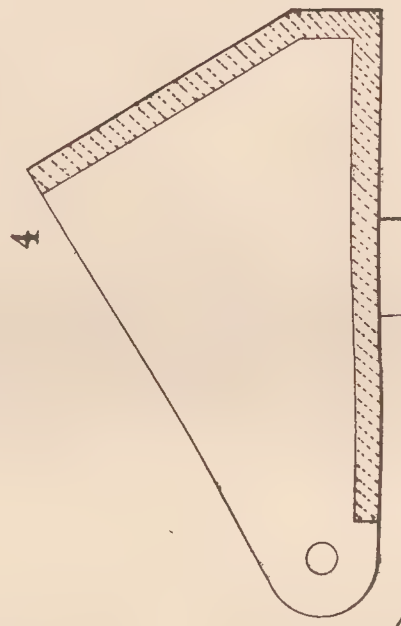
2



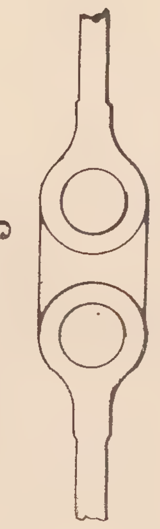
1



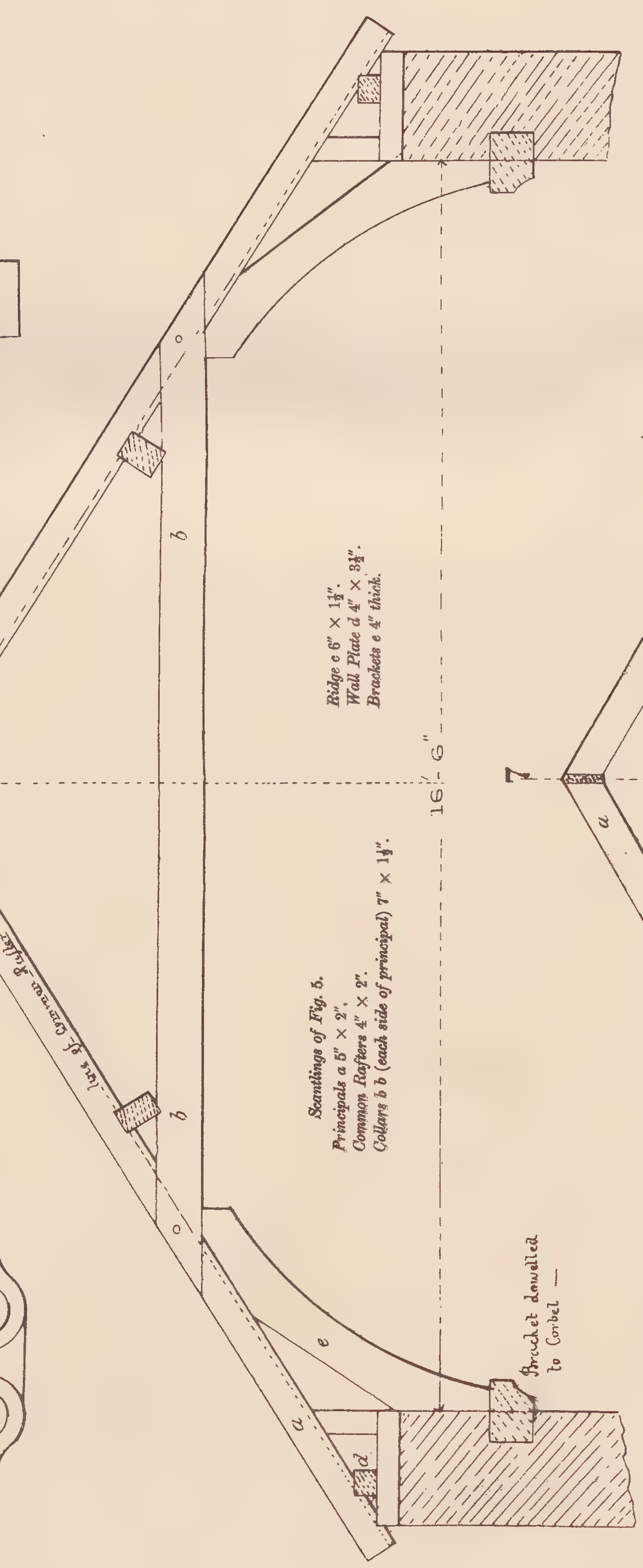
4



3

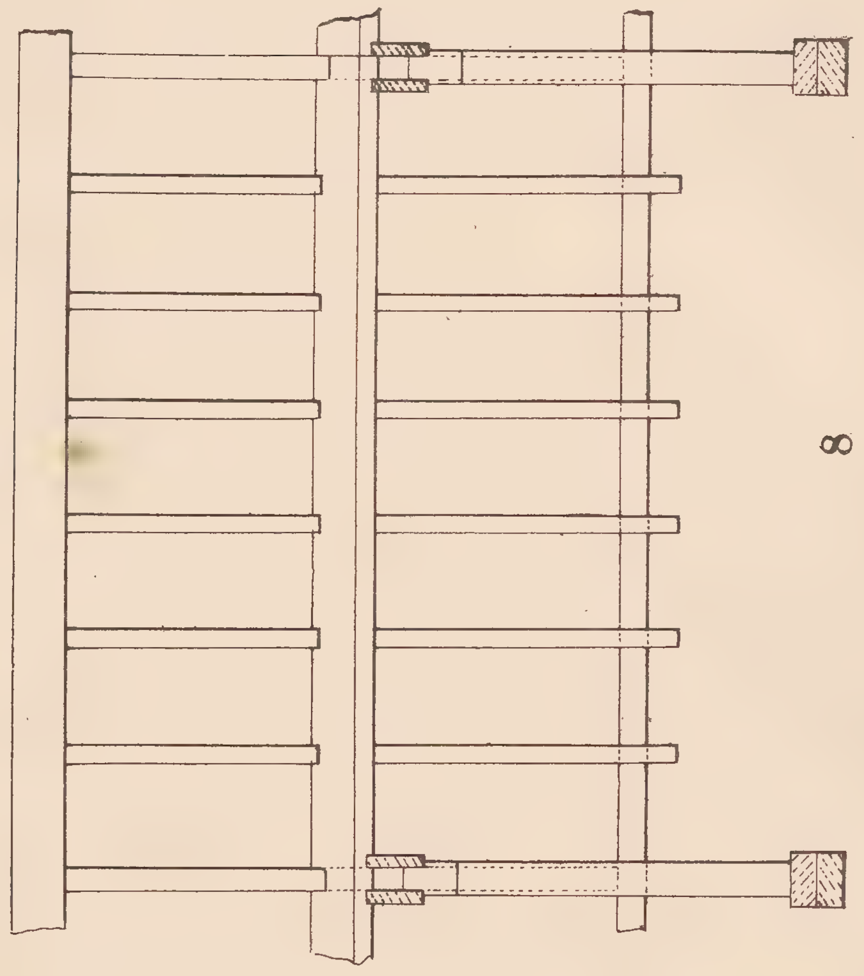


5

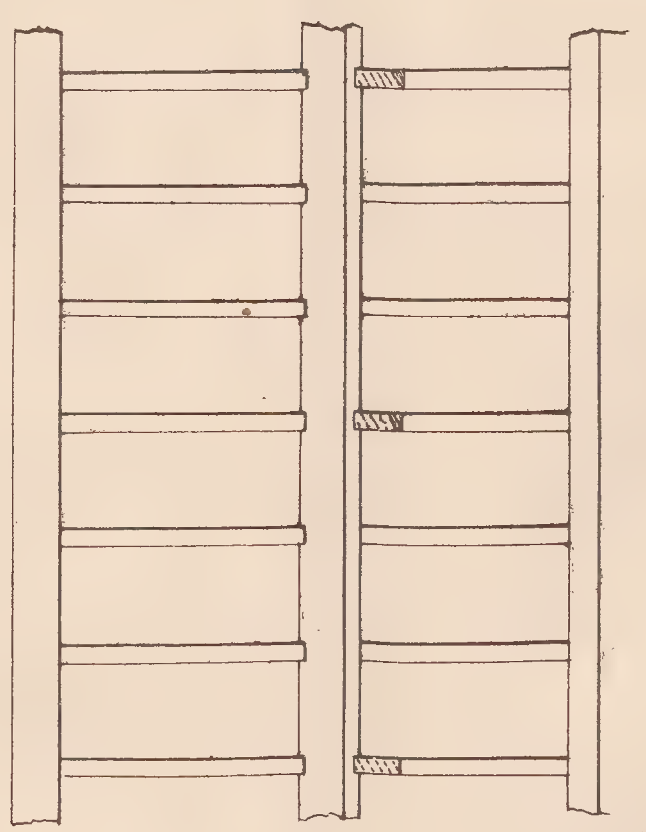

a
b
c
d
e
line of Common Rafter
16' 6"
Bracket dovetailed to Corbel —

Scantlings of Fig. 5.
Principals a 5" × 2".
Common Rafters 4" × 2".
Collars b b (each side of principal) 7" × 1½".
Ridge c 6" × 1½".
Wall Plate d 4" × 3½".
Brackets e 4" thick.

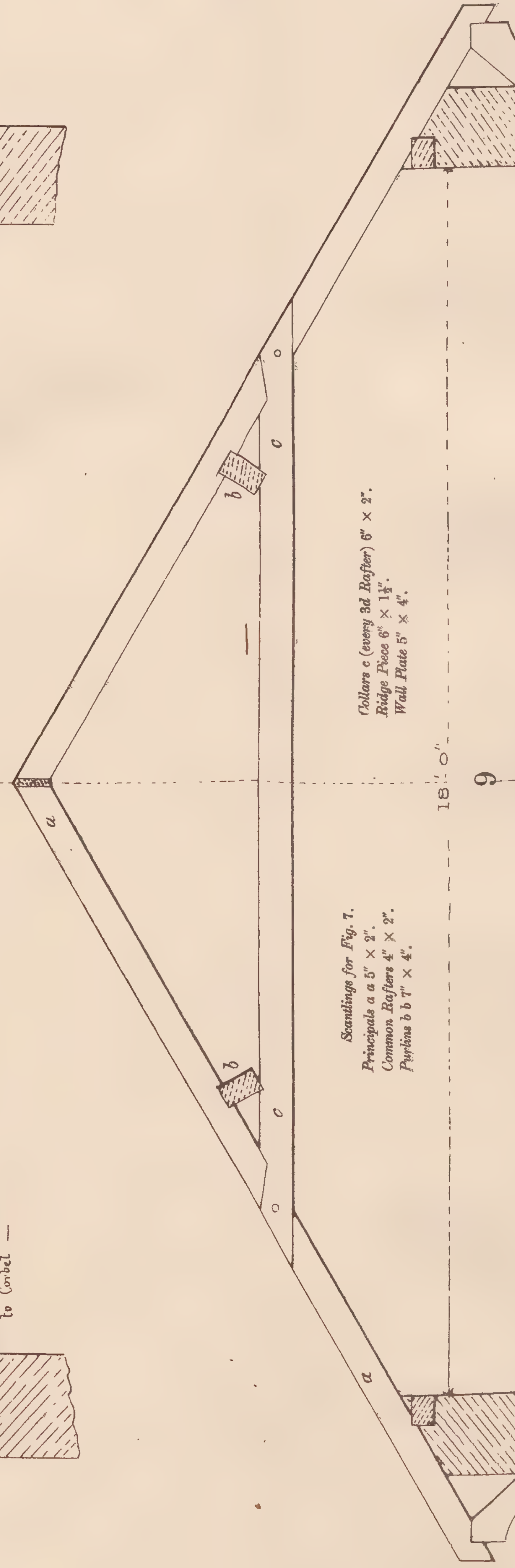
6



8

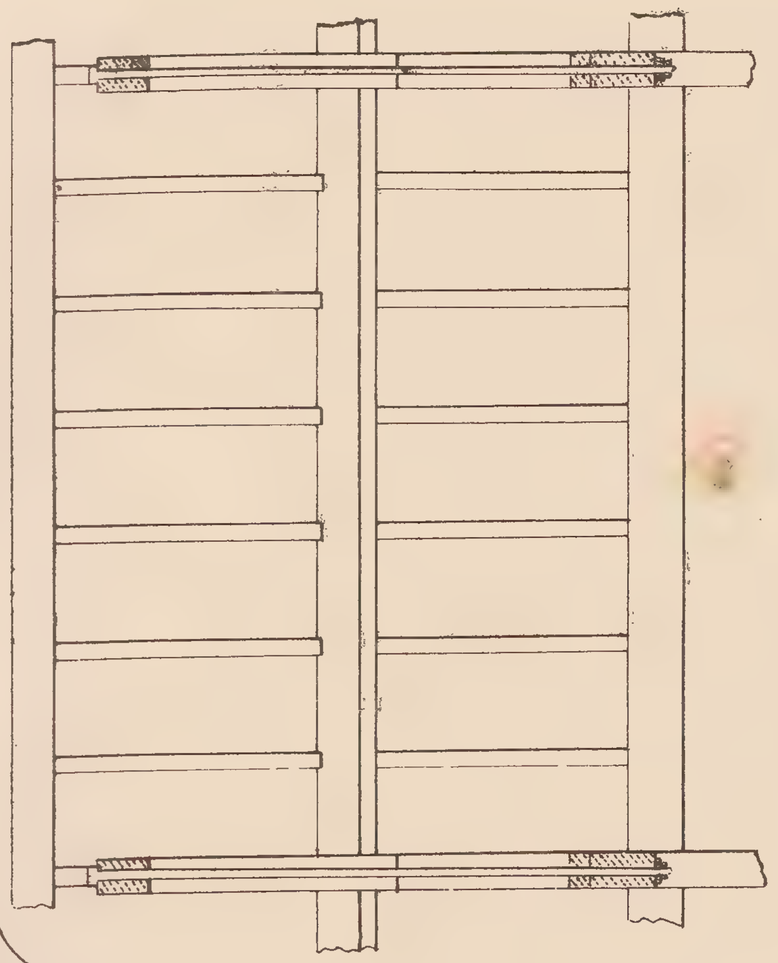


7

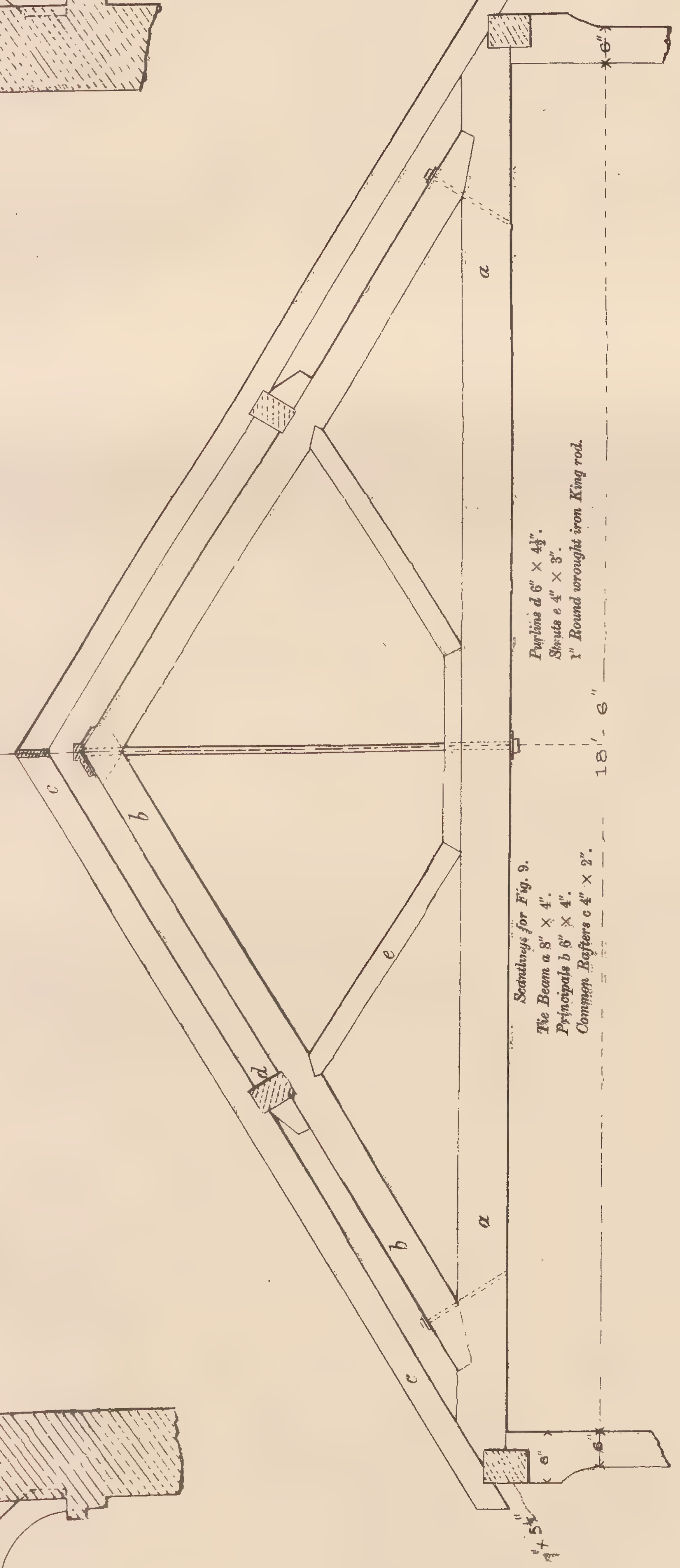


Scantlings for Fig. 7.
Principals a a 5" × 2".
Common Rafters 4" × 2".
Purlins b b 7" × 4".
Collars c (every 3d Rafter) 6" × 2".
Ridge Piece 6" × 1½".
Wall Plate 5" × 4".

10

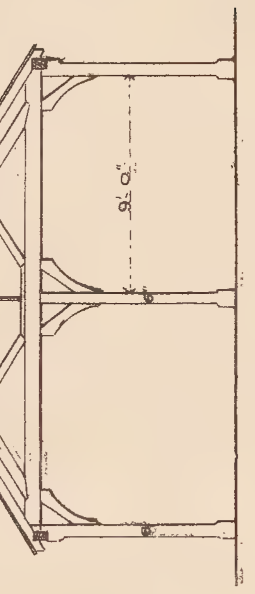


9

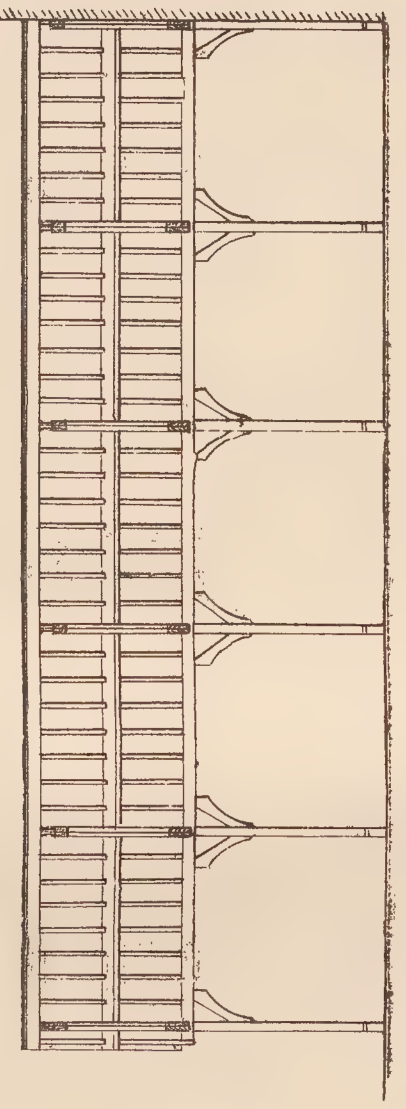

a
b
c
d
e
18' 6"
6"
1' 5½"

Scantlings for Fig. 9.
Tie Beam a 8" × 4".
Principals b 6" × 4".
Common Rafters c 4" × 2".
Purlins d 6" × 4½".
Struts e 4" × 3".
1" Round wrought iron King rod.

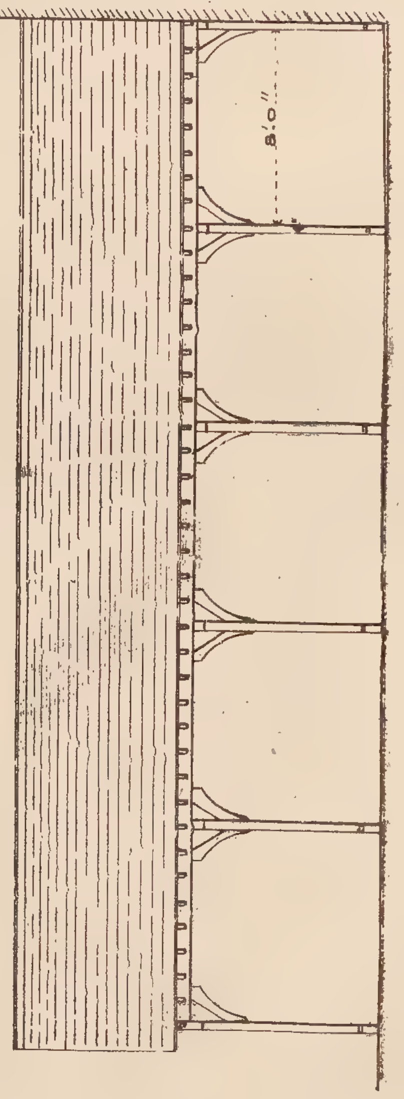
13



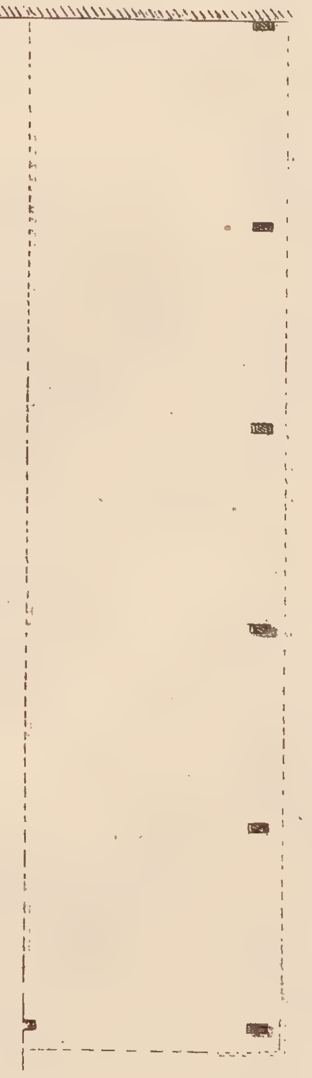
12

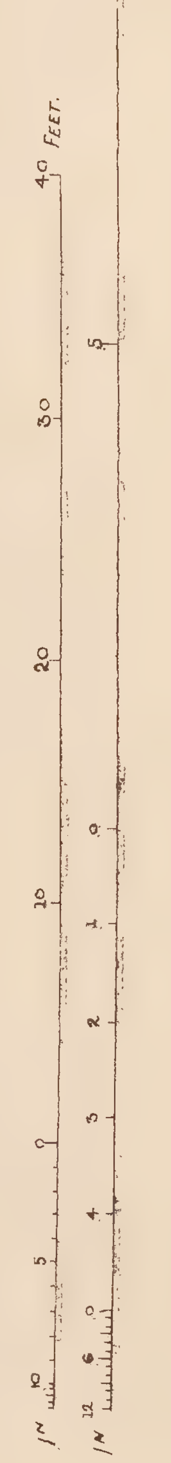


11



14




FEET
FEET
40
30
20
10
5
0
15
10
5
0
1"
1"

REFERENCE.

FIG. 1. ELEVATION OF LOUVRE BOARDS UNDER ARCHWAYS.
" 2. SECTION OF DITTO ON LINE A B.
" 3. DETAILED PLAN OF JUNCTION OF TIE ROD AND SUSPENSION RODS.
" 4 SECTION OF CAST-IRON SHOE TO RECEIVE SPRINGING STONE.

Scale 1-6th Full Size.

" 5. COLLAR BEAM ROOF WITH BRACKETS AND CORBELS AT SPRINGING.
6. SECTION OF DITTO, DITTO.
FIG. 7. COLLAR BEAM ROOF WITH OVERHANGING EAVES.
" 8. SECTION OF FIG. 7.
" 9. OPEN SHED ROOF WITH TIE BEAM AND WROUGHT IRON KING-ROD.
" 10. SECTION OF DITTO, DITTO.
" 11. SKETCH OF OPEN SHED ⅛" SCALE.
" 12. SECTION OF DITTO.
" 13. TRANSVERSE SECTION OF DITTO.
" 14. HALF PLAN OF DITTO.

A. FULLARTON & Cº LONDON AND EDINBURGH

WINDOWS & DOORS FOR COW-HOUSES & STABLES.

PLATE XLIV.

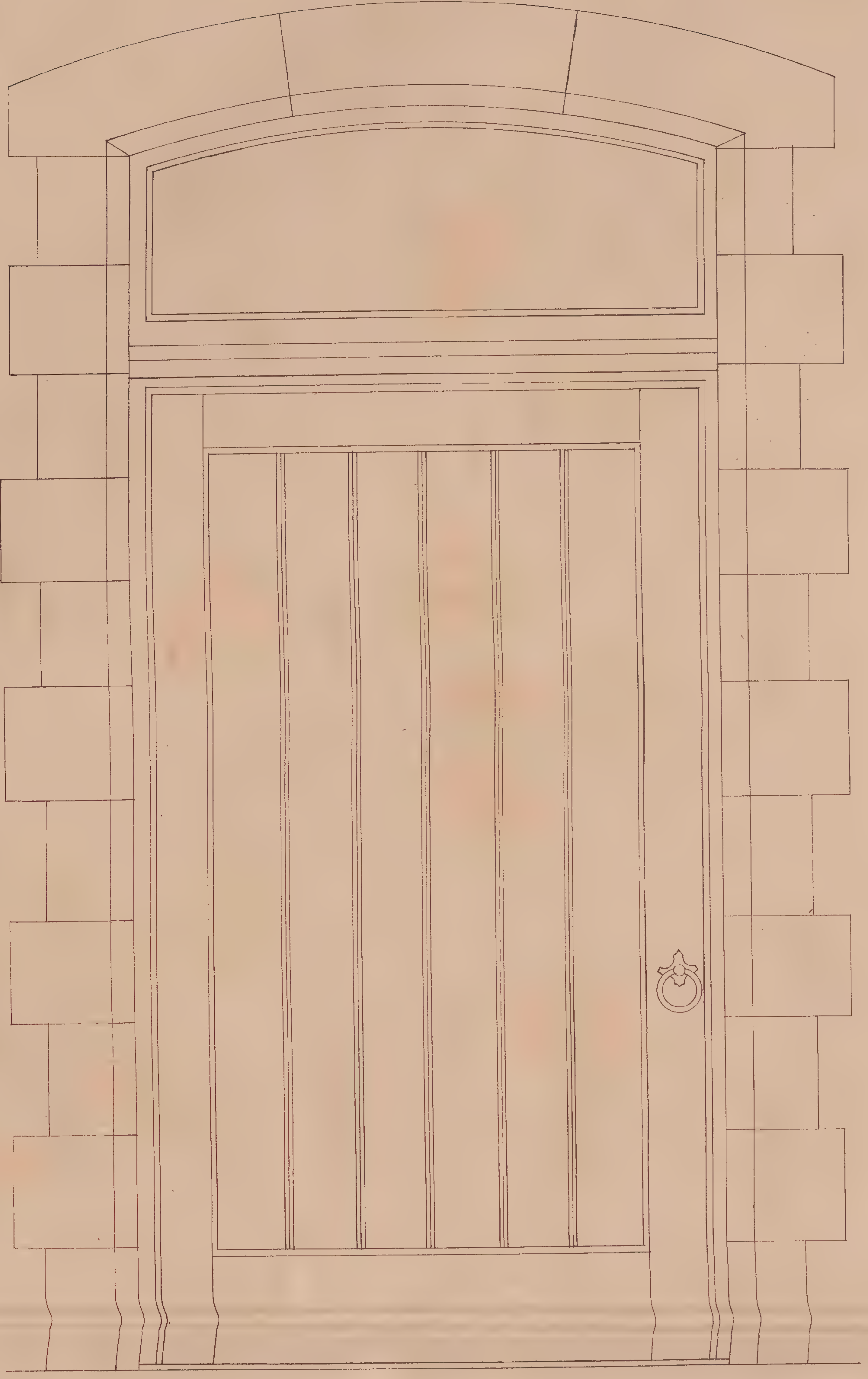


FIG. 1.
EXTERNAL ELEVATION OF DOOR.

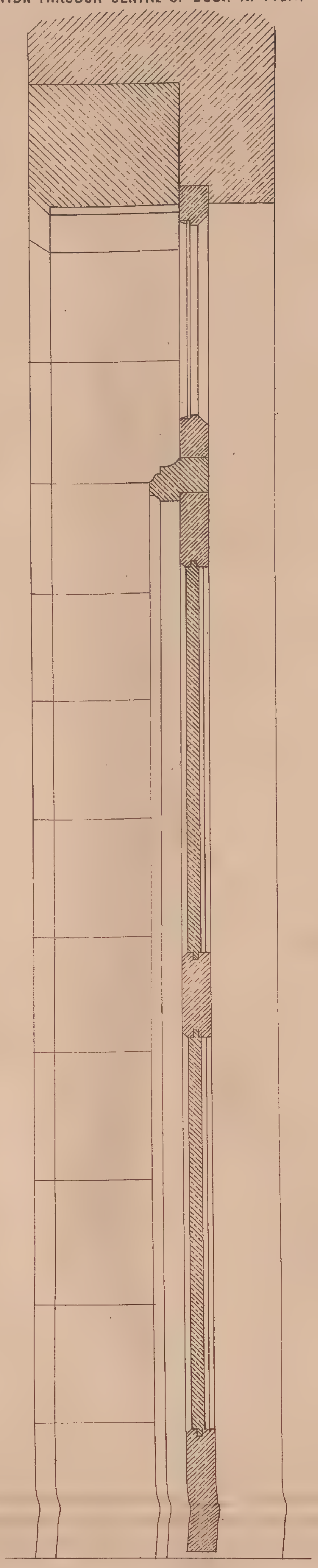


FIG. 2.
SECTION THROUGH CENTRE OF DOOR IN FIG. 1.

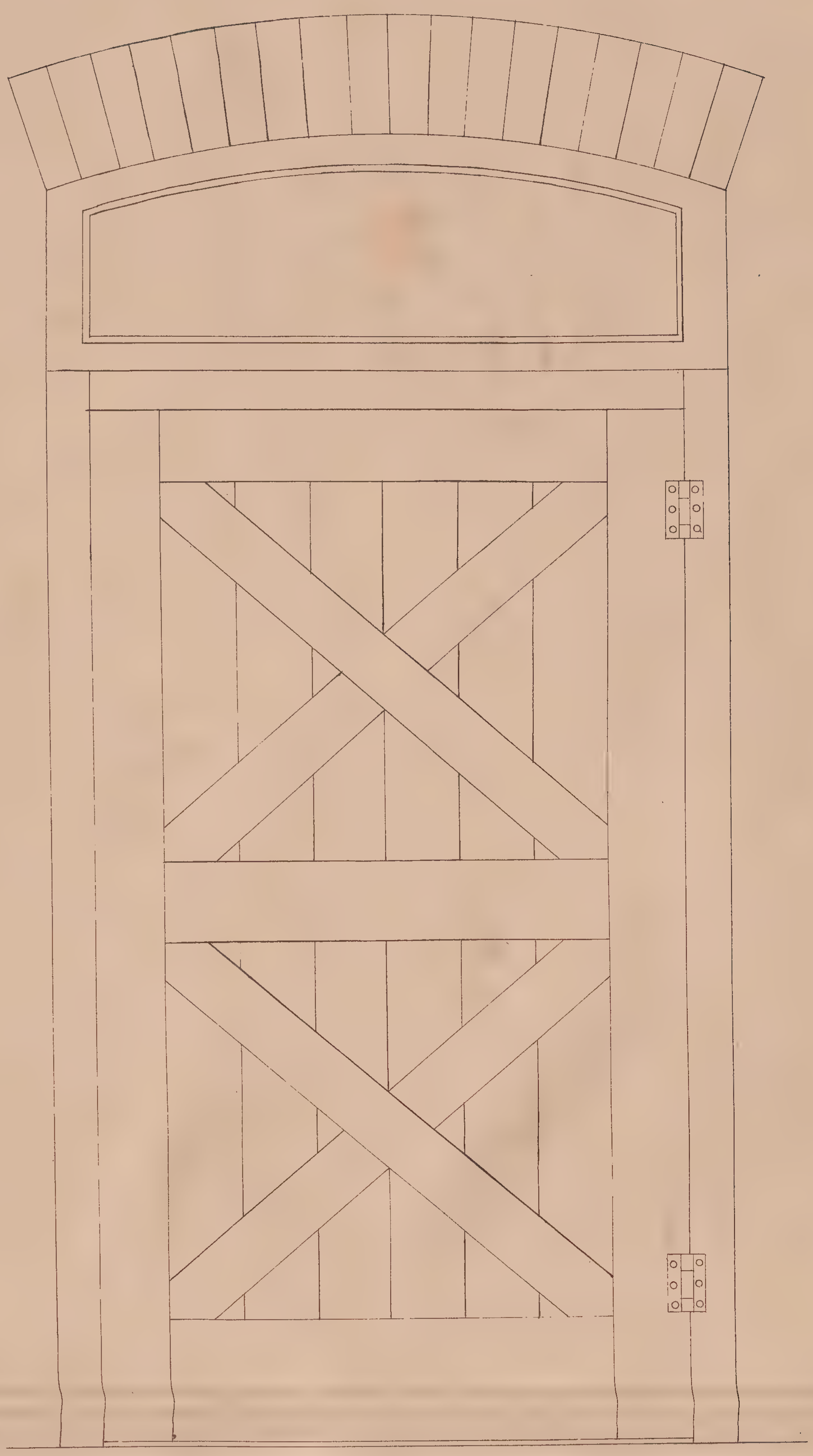


FIG. 3.
INTERNAL ELEVATION OF DOOR IN FIG. 1.

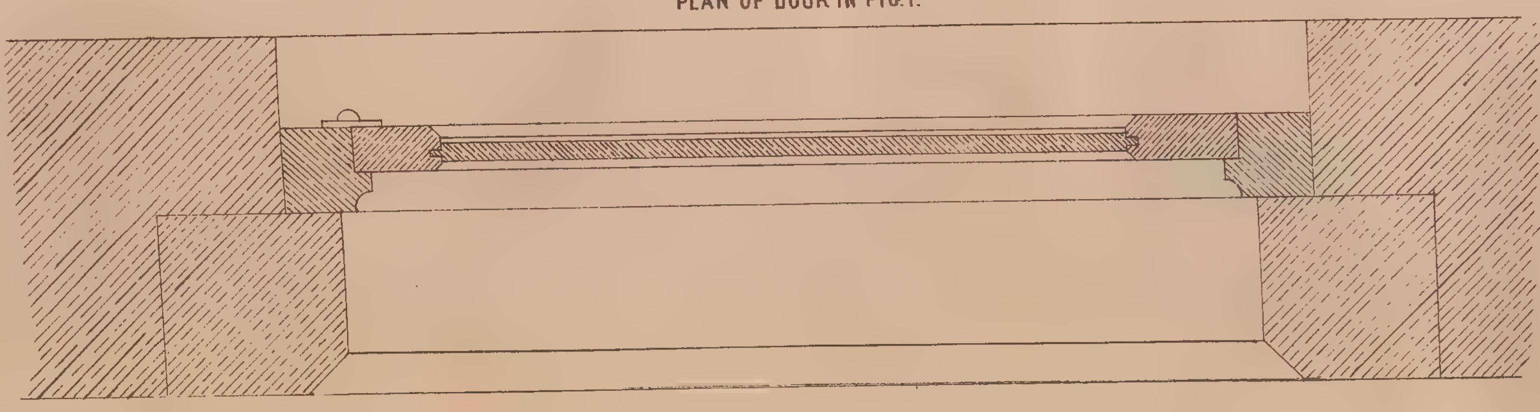


FIG. 4.
PLAN OF DOOR IN FIG. 1.

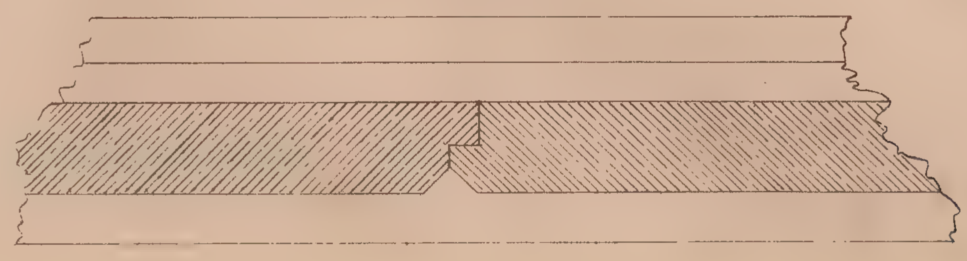
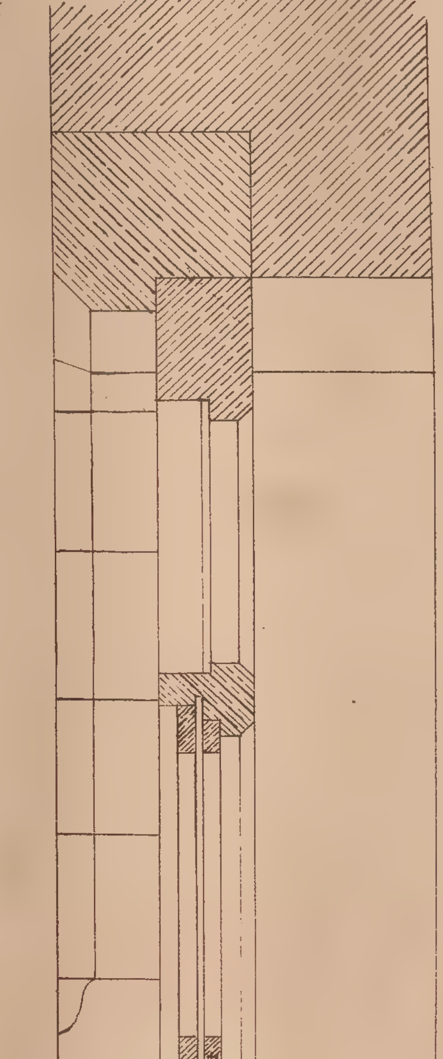


FIG. 5.
JOINTED BOARDING AT A A, FIG. 1.


SECTION THROUGH CENTRE OF WINDOW IN FIG. 6.

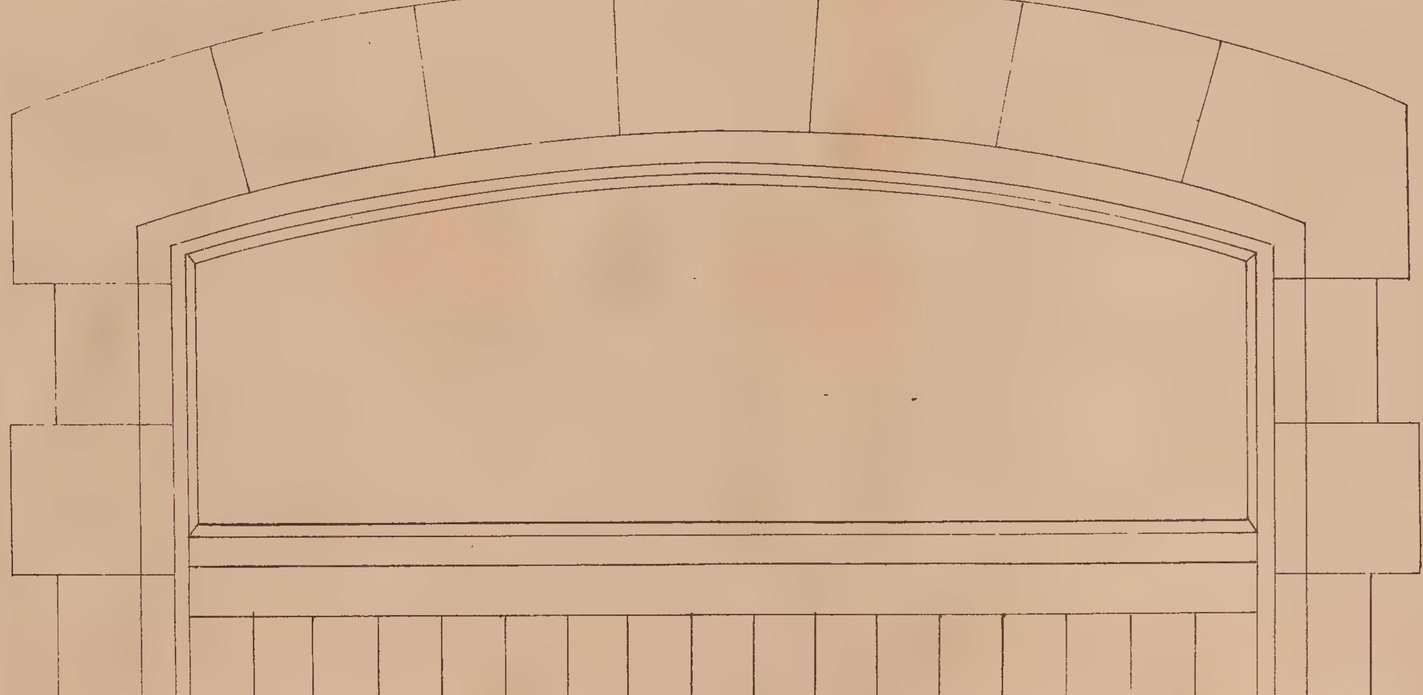


FIG. 6.
EXTERNAL ELEVATION OF WINDOW.

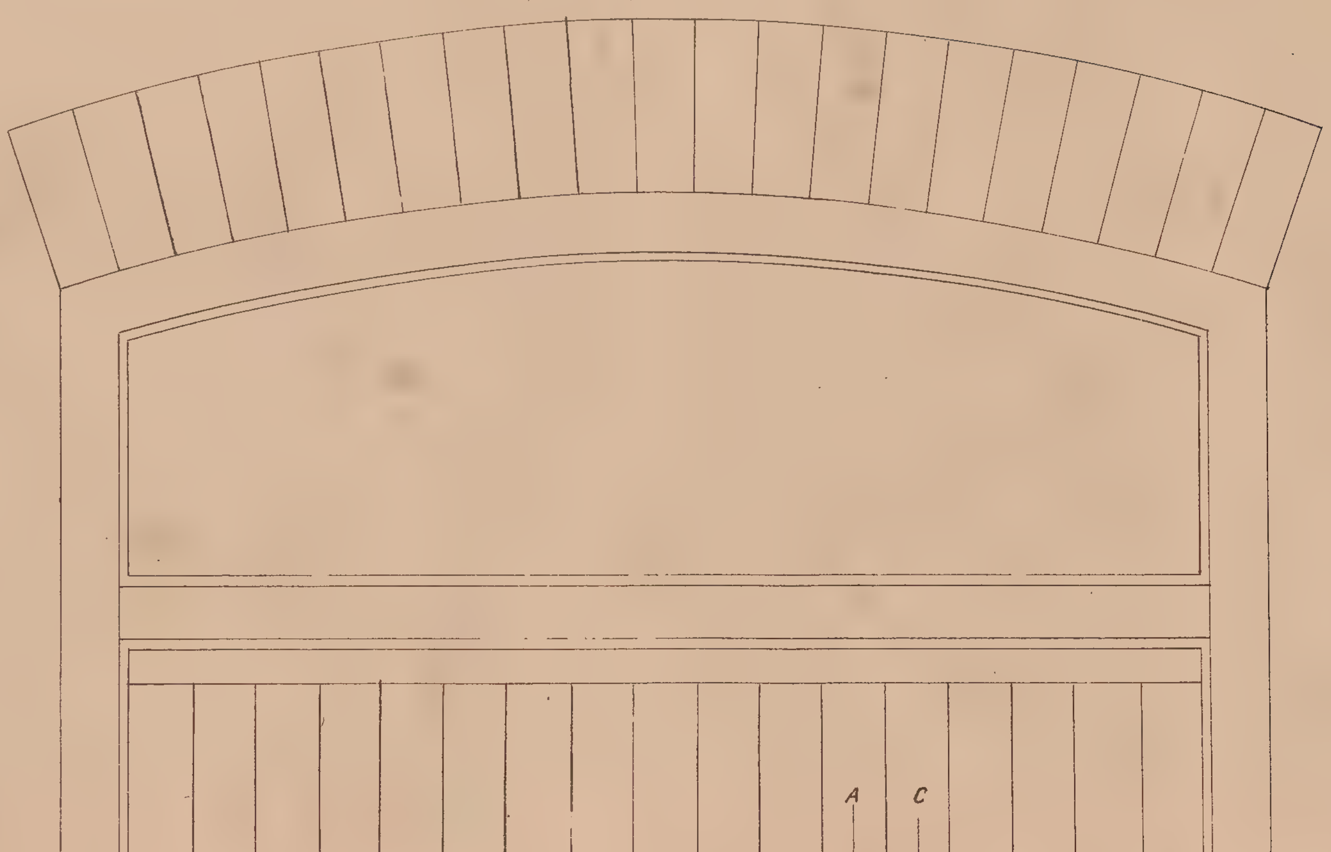


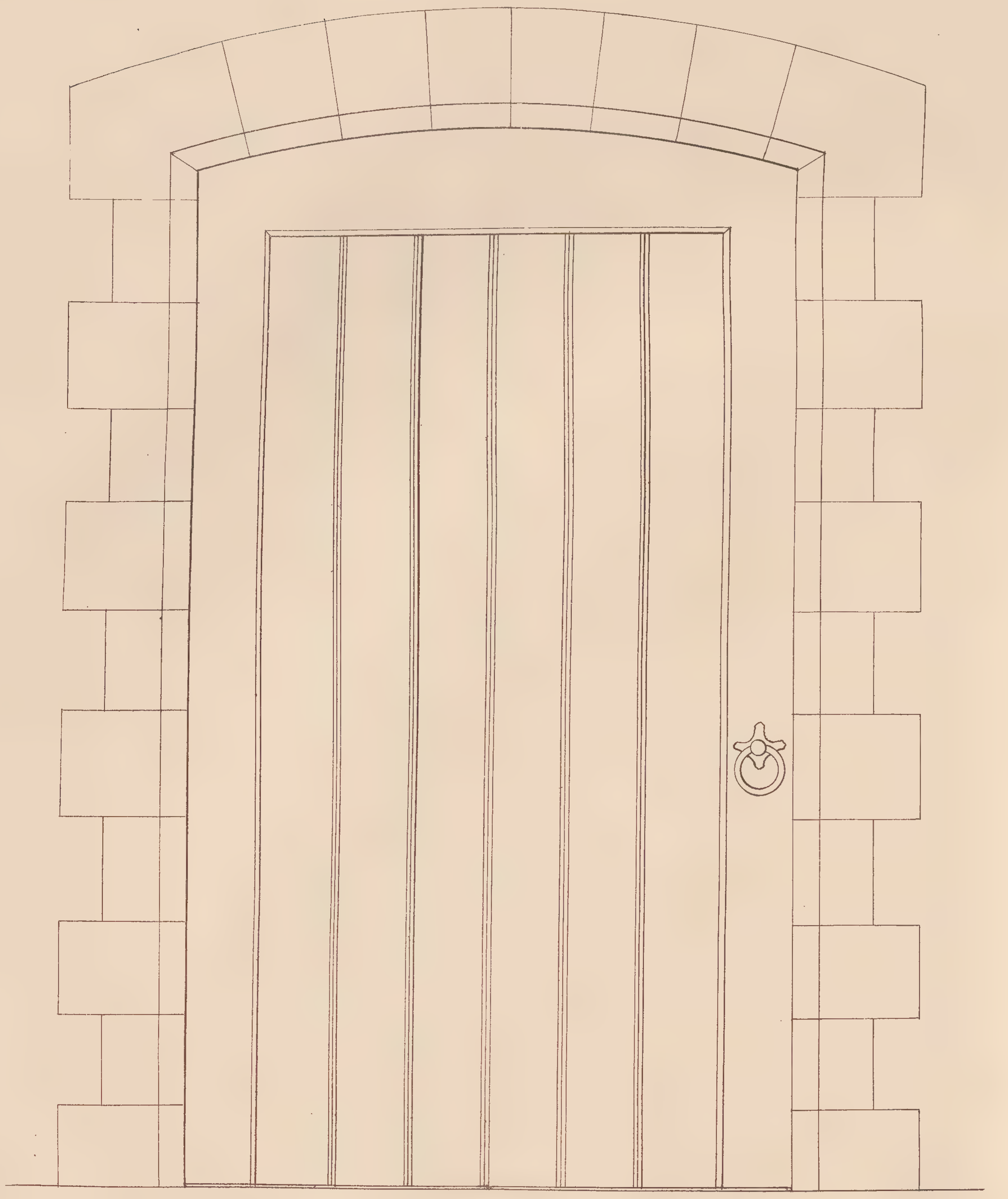
FIG. 7.
INTERNAL ELEVATION OF WINDOW IN FIG. 6.

SCALE FOR FIGS. 1 TO 7.

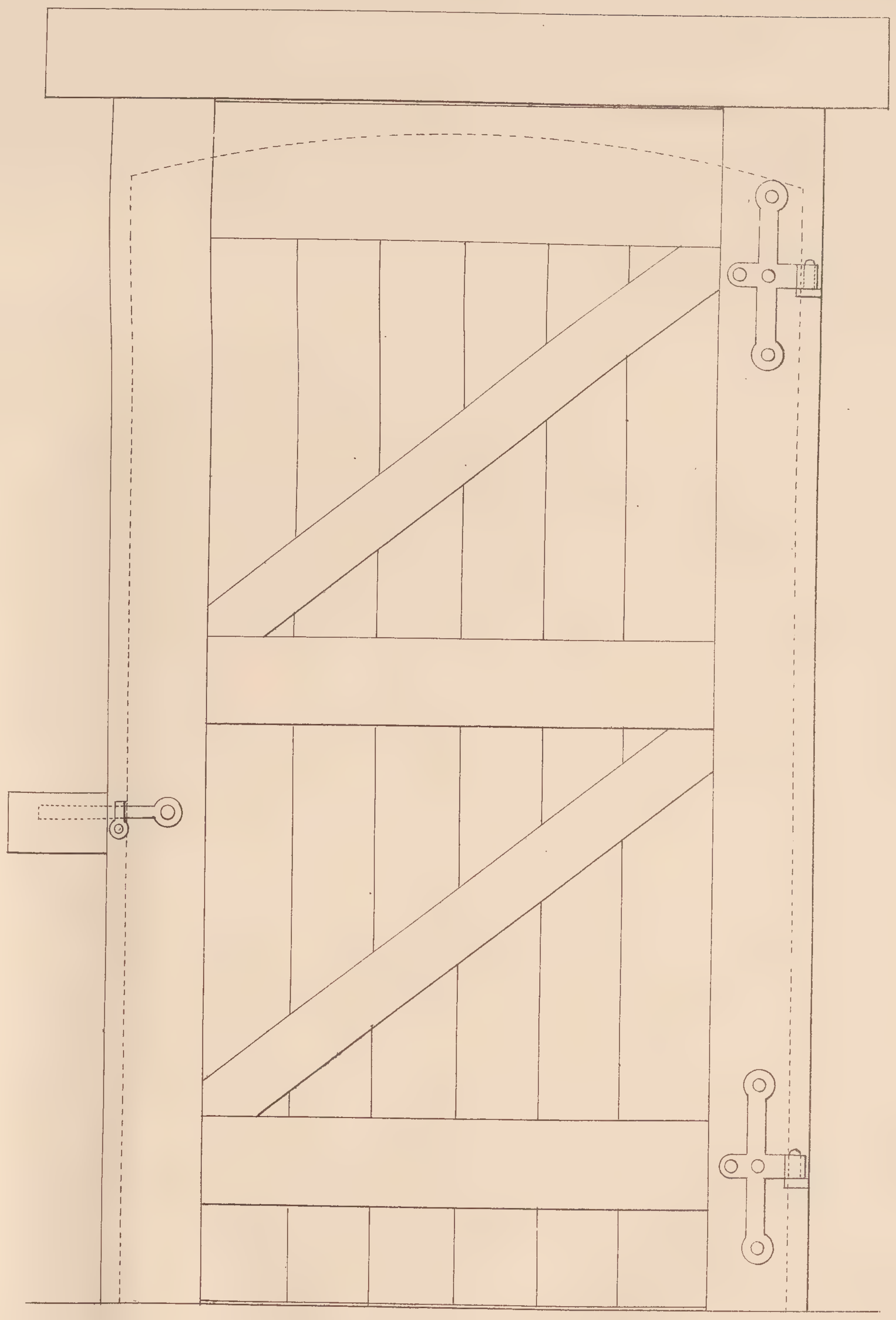
12
9
6
3
0
1
2
3
4
In
Ft

DOORS OF COW HOUSES AND STABLES AND DETAILS OF WINDOWS IN PLATE XLIV

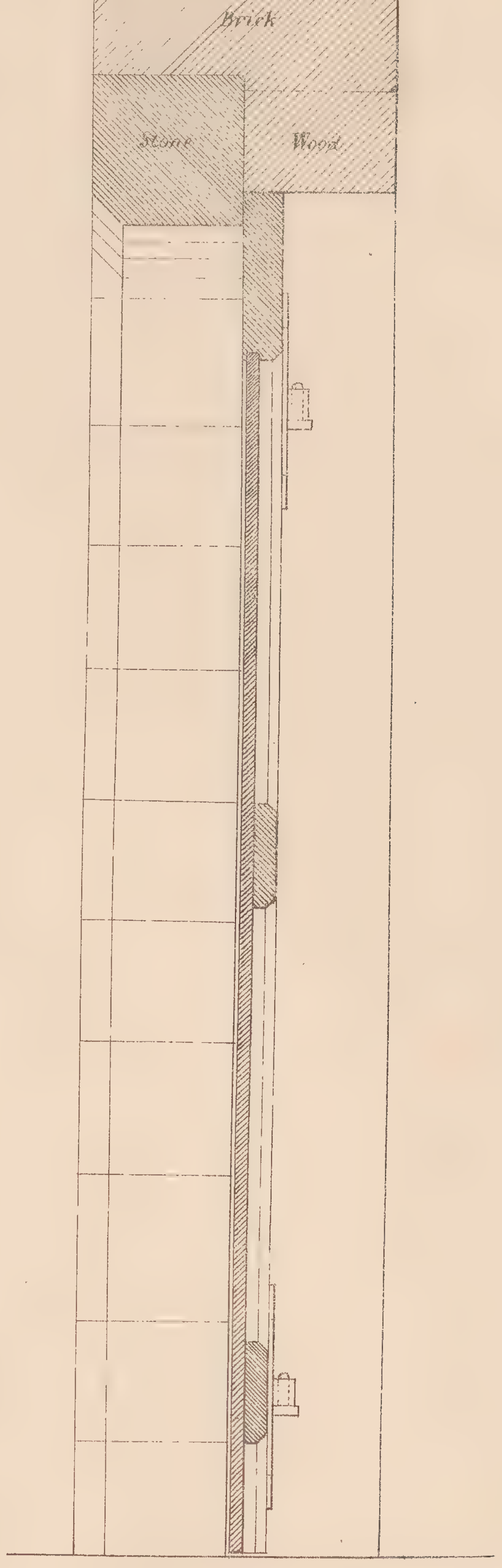
(1.)
EXTERNAL ELEVATION OF DOOR.



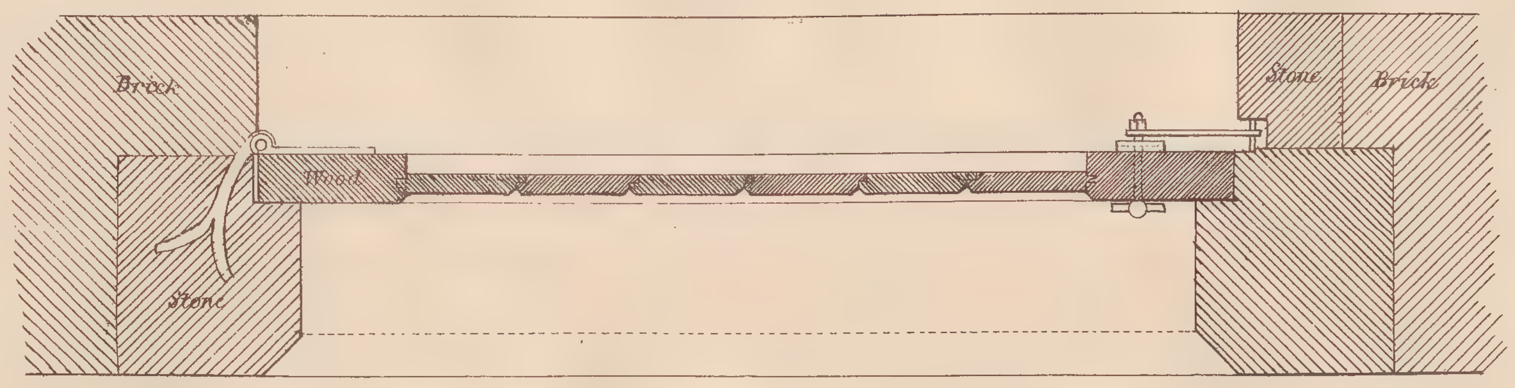
(2.)
INTERNAL ELEVATION OF DOOR.



(3)
SECTION THROUGH CENTRE OF DOOR

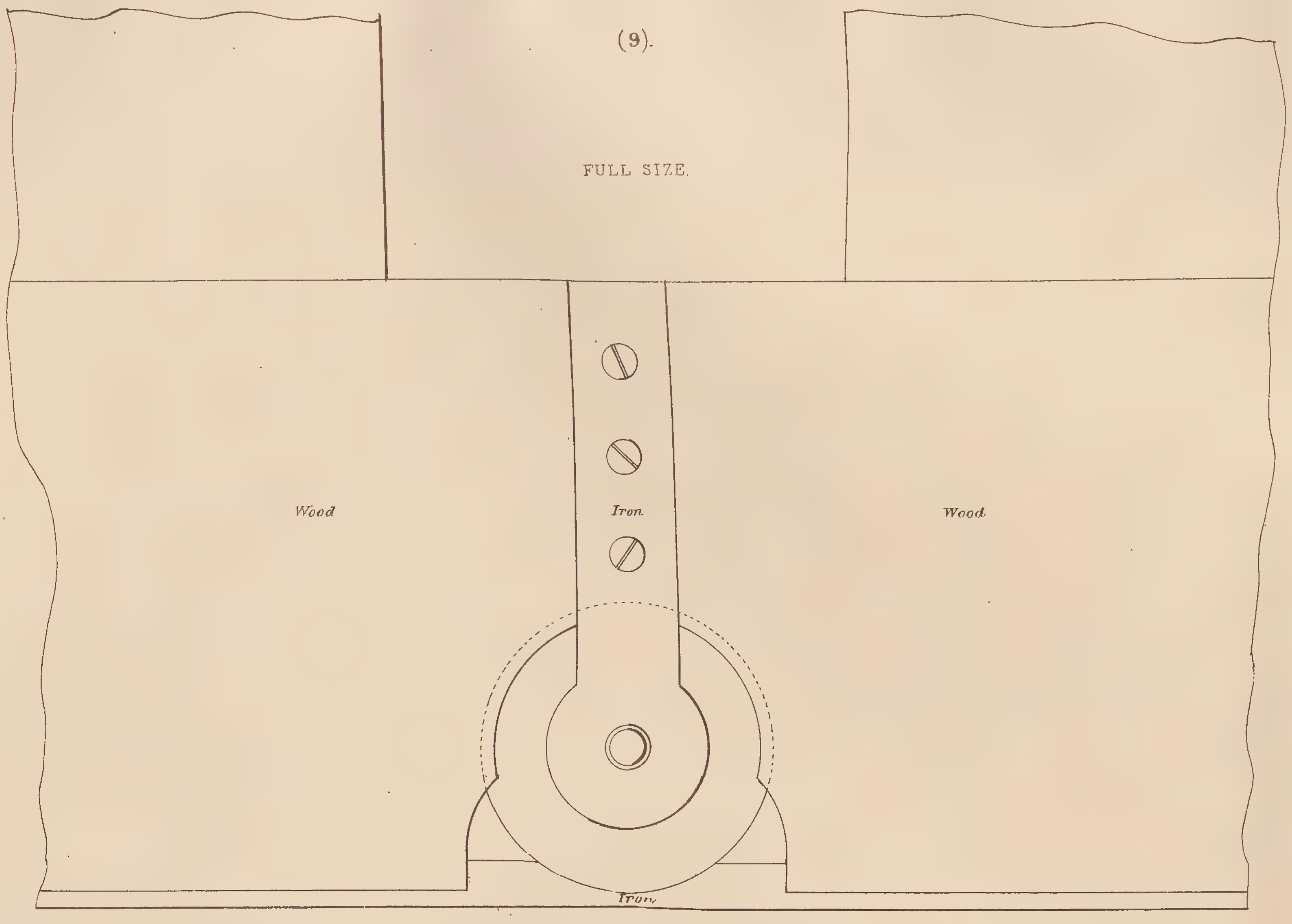

Brick
Stone
Wood

(4.)
PLAN OF DOOR.


Brick
Wood
Stone
Stone
Brick

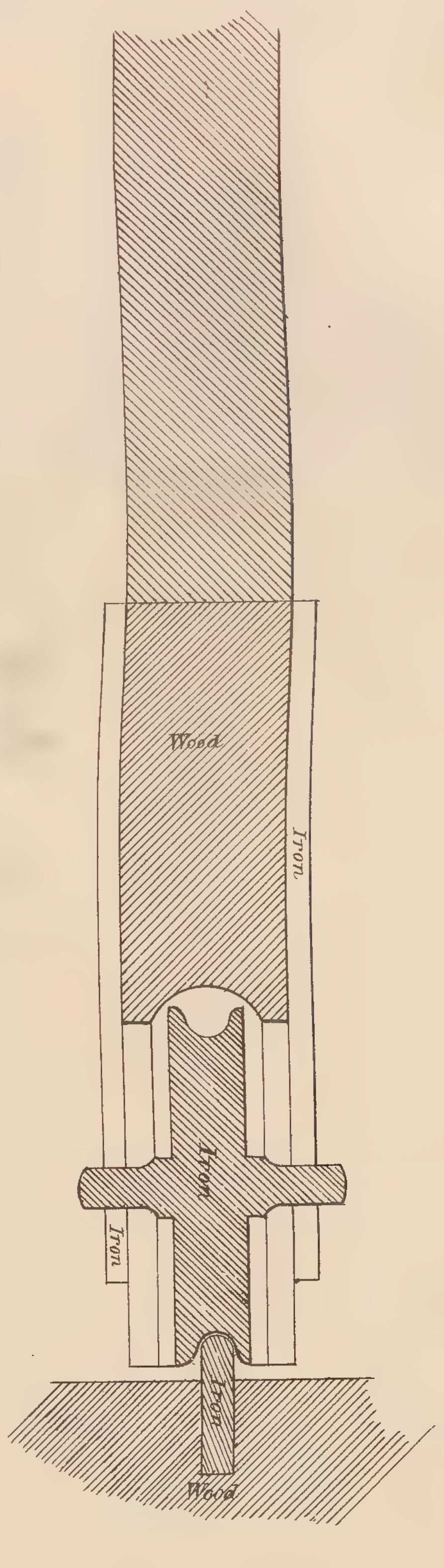
(9).

FULL SIZE.

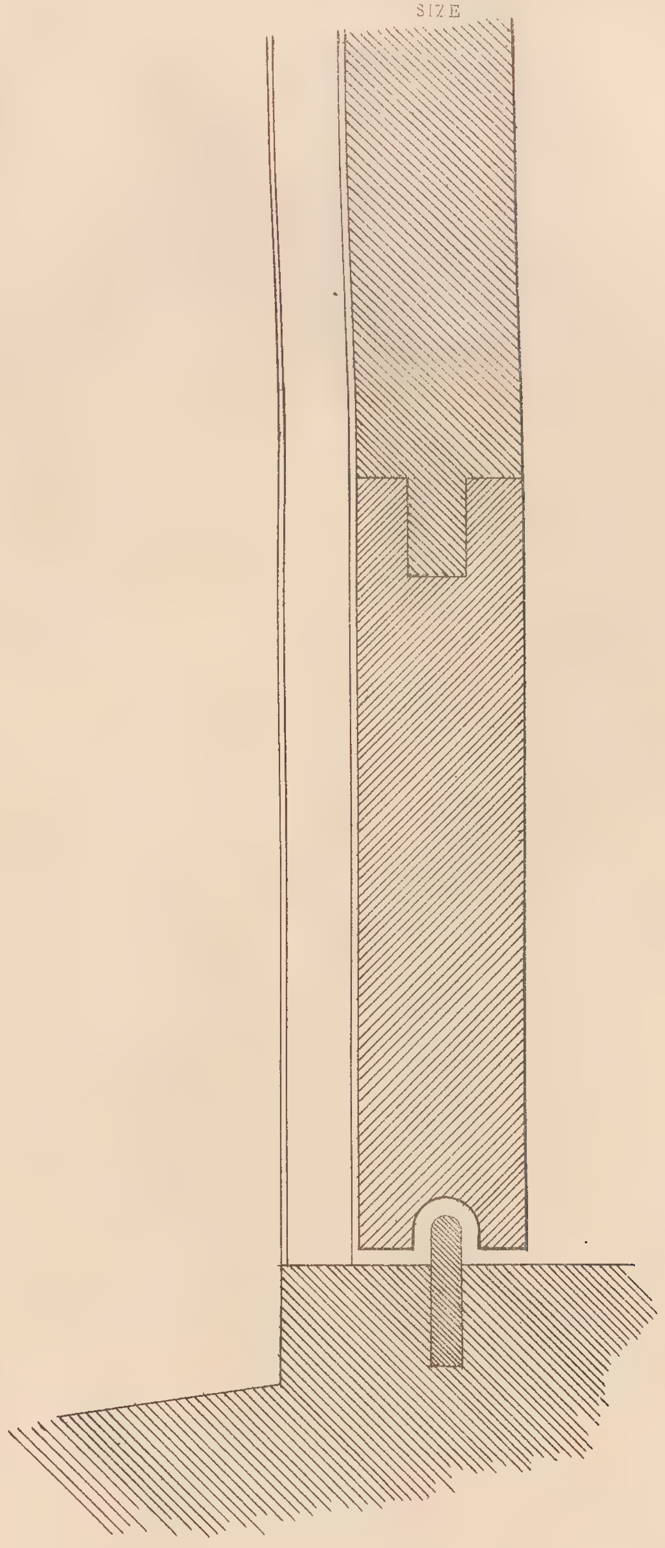

Wood
Iron
Wood
Iron

SIDE ELEVATION OF SLIDE ROLLER OF WINDOW
FIG. 6, PLATE XLIX.

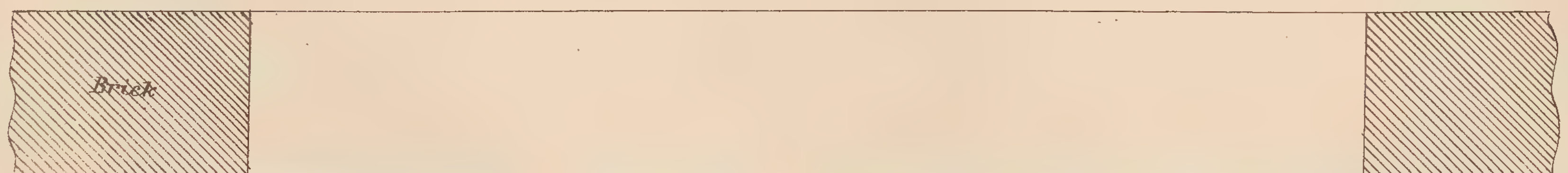
(7.)
SECTION OF BOTTOM SLIDE ROLLERS OF WINDOW
THROUGH LINE A B FIG. 6, PLATE XLIX,
FULL SIZE.


Wood
Iron
Iron
Iron
Iron
Wood

(8.)
SECTION OF BOTTOM RAIL OF WINDOW
AT C D FIG. 6 PLATE XLIX, FULL
SIZE

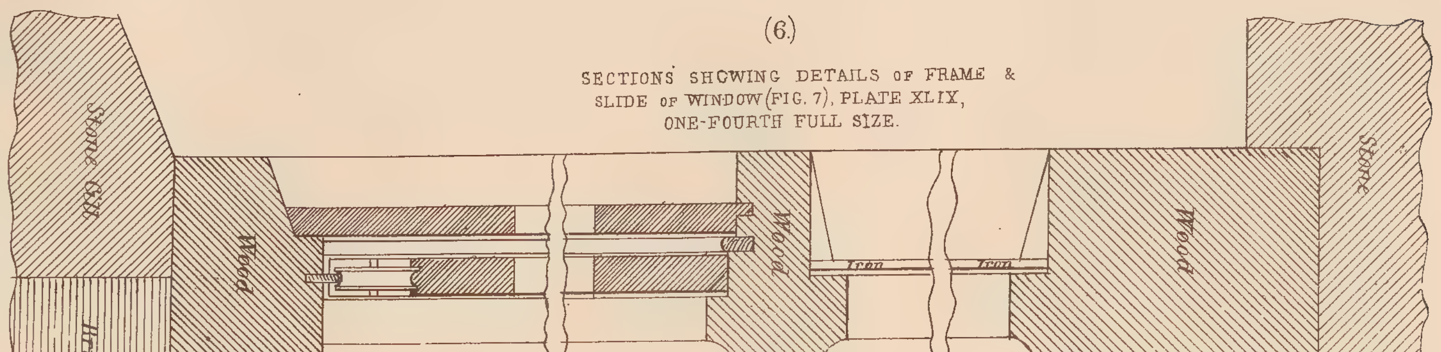


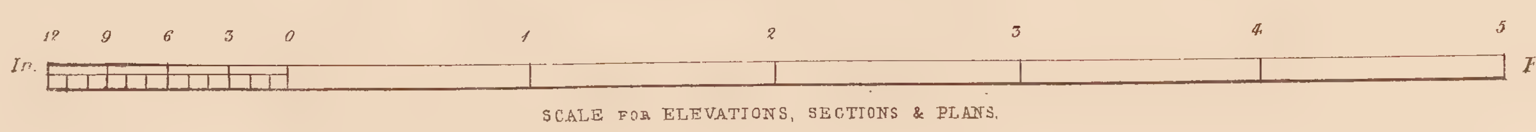
(5.)


Brick
Wood
Stone

PLAN OF WINDOW ELEVATION (FIG. 7) PLATE XLIX.

(6.)
SECTIONS SHOWING DETAILS OF FRAME &
SLIDE OF WINDOW (FIG. 7). PLATE XLIX,
ONE-FOURTH FULL SIZE.


Stone Sill
Brick
Wood
Wood
Iron
Iron
Wood
Stone


12 9 6 3 0
1
2
3
4
5
In.
Feet.

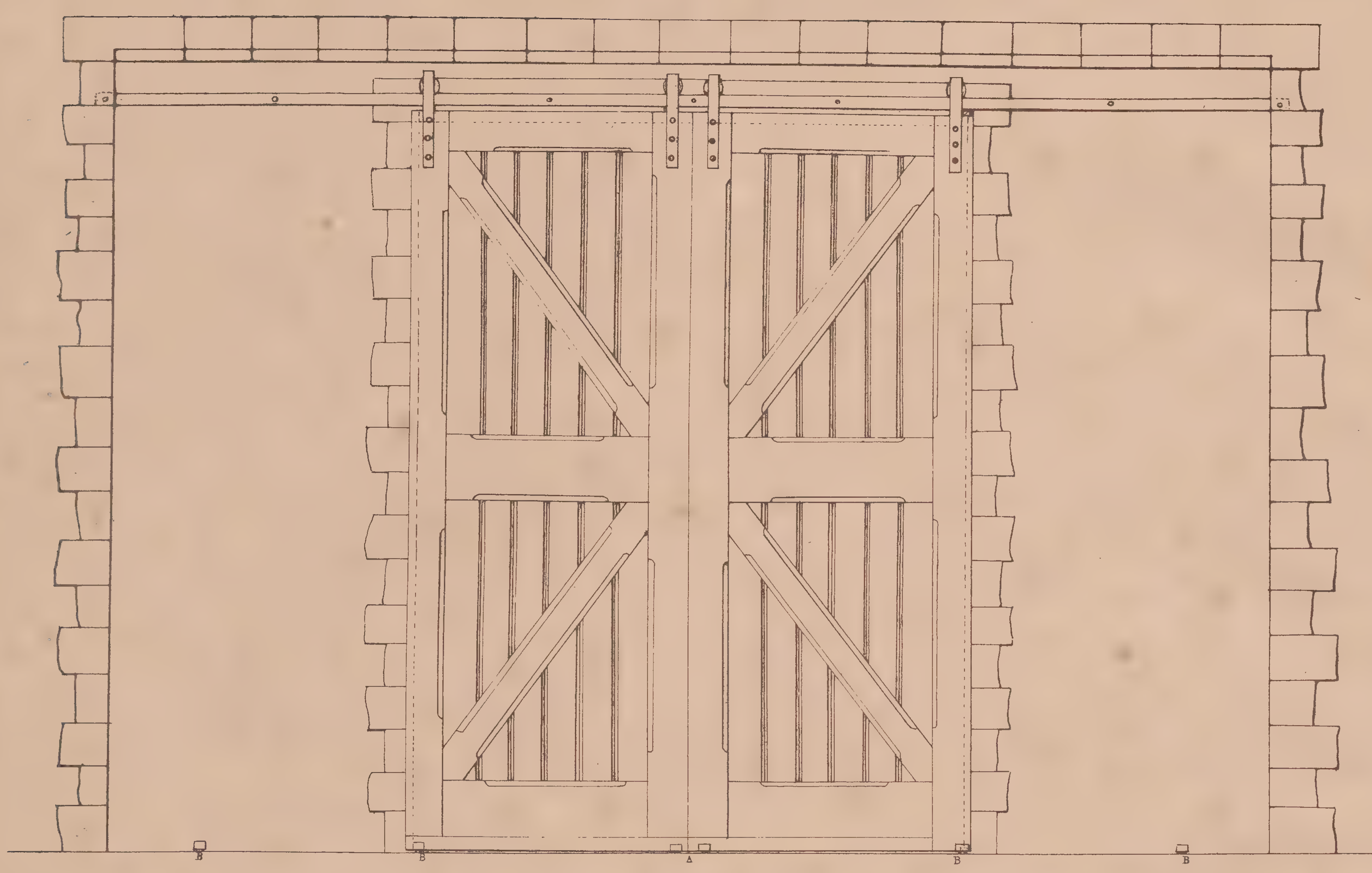
SCALE FOR ELEVATIONS, SECTIONS & PLANS.

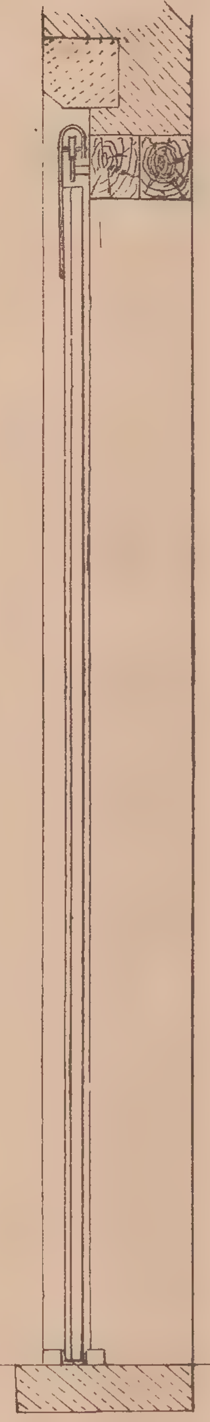
A. FULLARTON & CO. LONDON AND EDINBURGH.

DOUBLE SLIDING DOORS OF TIMBER FOR BARNS, STORES, &c.

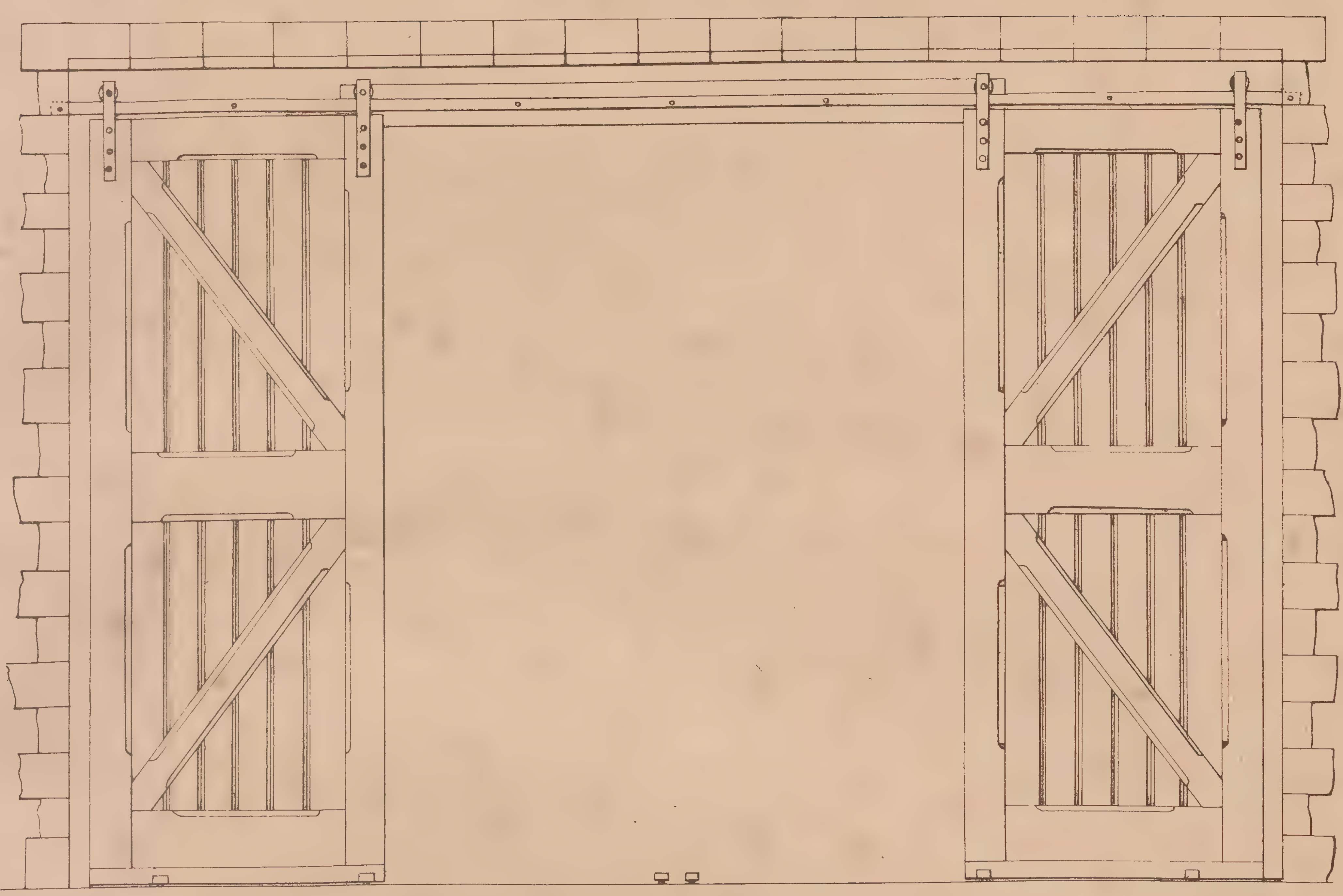
PLATE XLVI.

EXTERIOR ELEVATION CLOSED 1

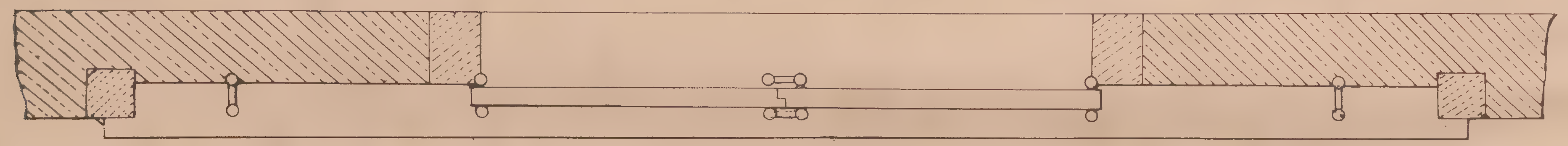




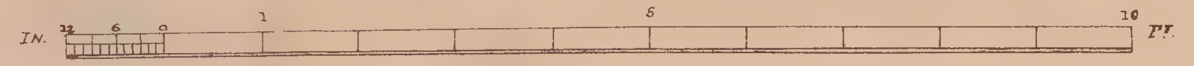
EXTERNAL ELEVATION OF DOORS—OPEN 2



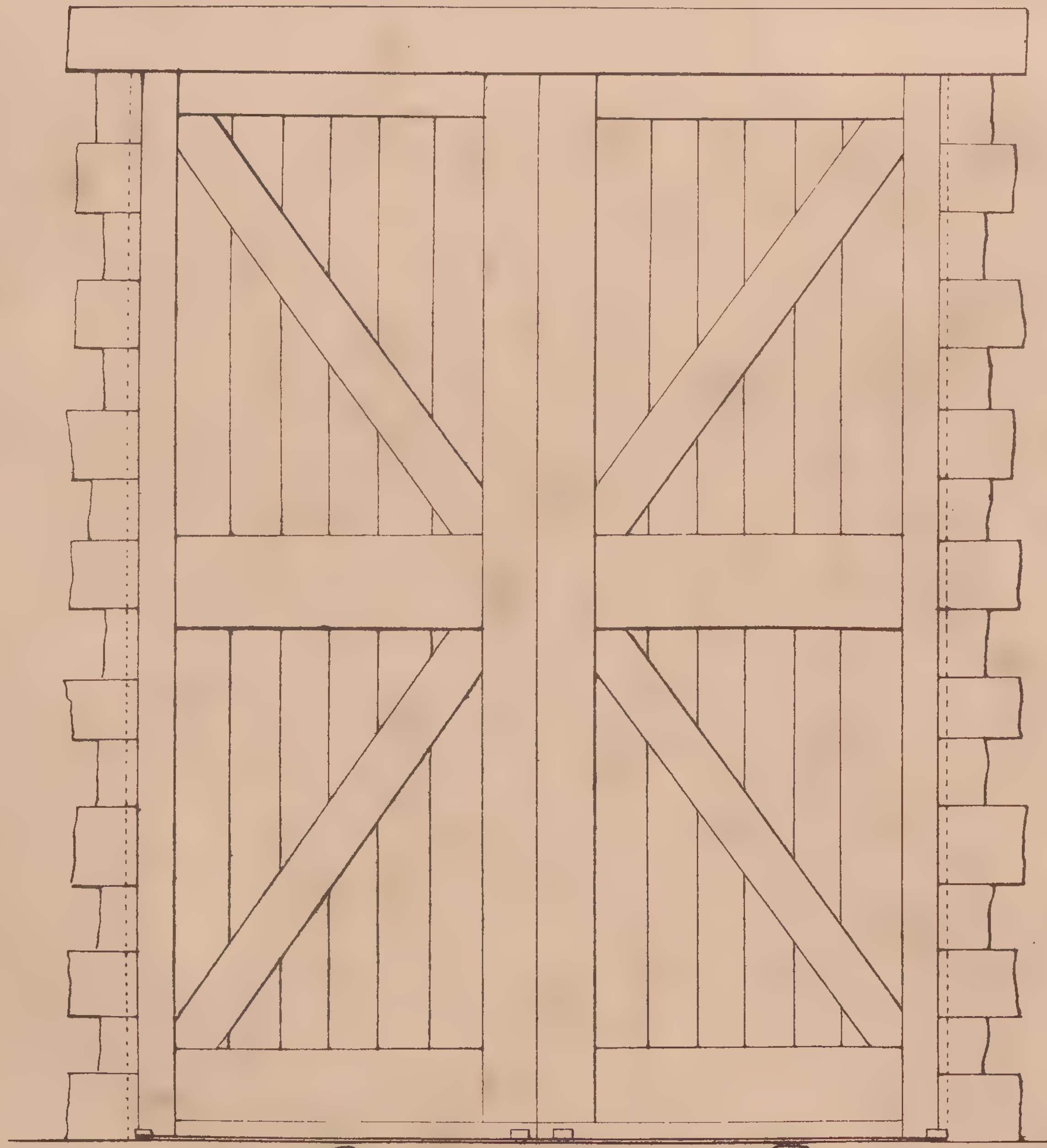
PLAN OF DOOR 4

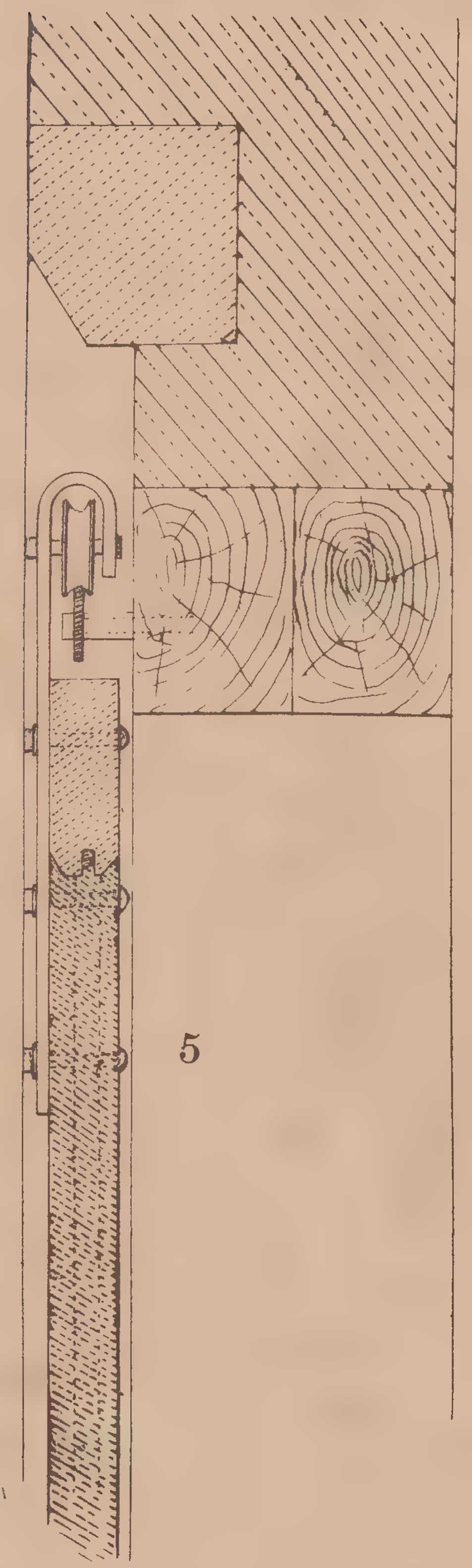


SCALE FOR ELEVATIONS AND PLAN



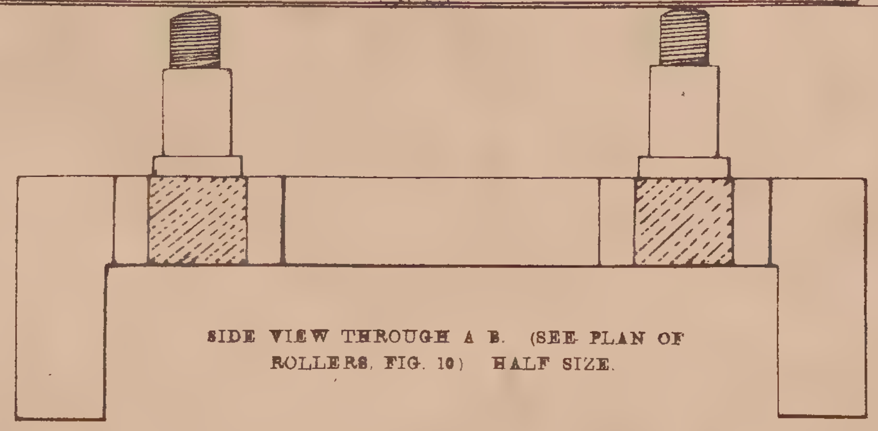
INTERIOR ELEVATION CLOSED 3





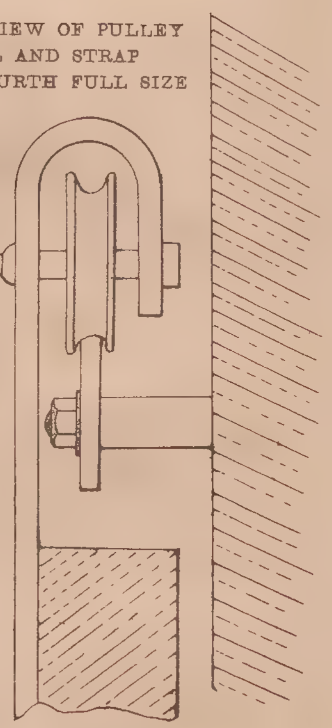
5

UPPER PART OF DOOR SHOWING BREST SUMMER.
ONE-EIGHTH FULL SIZE



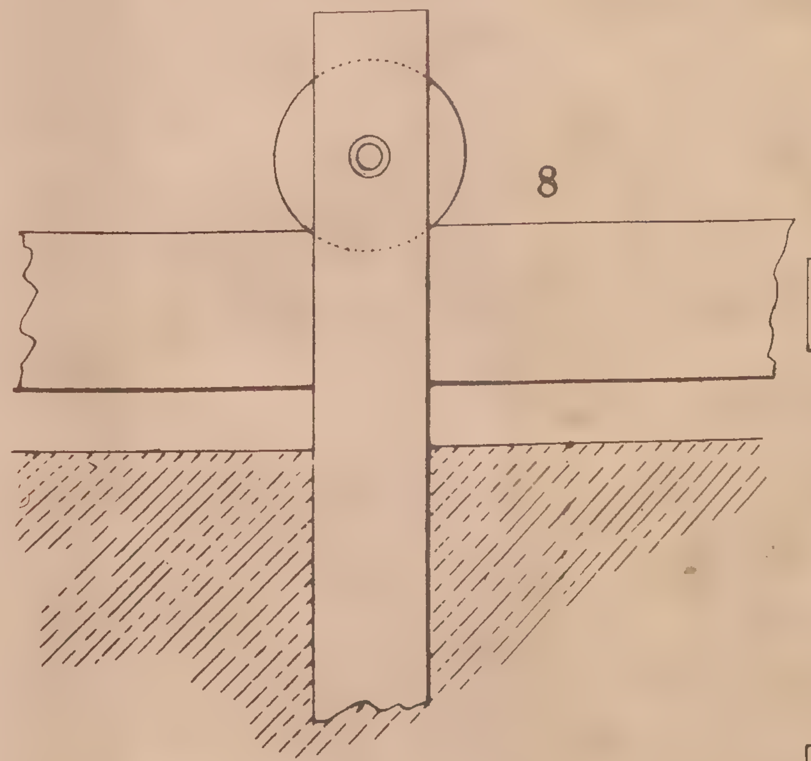
SIDE VIEW THROUGH A B. (SEE PLAN OF ROLLERS, FIG. 10) HALF SIZE.

END VIEW OF PULLEY RAIL AND STRAP ONE FOURTH FULL SIZE

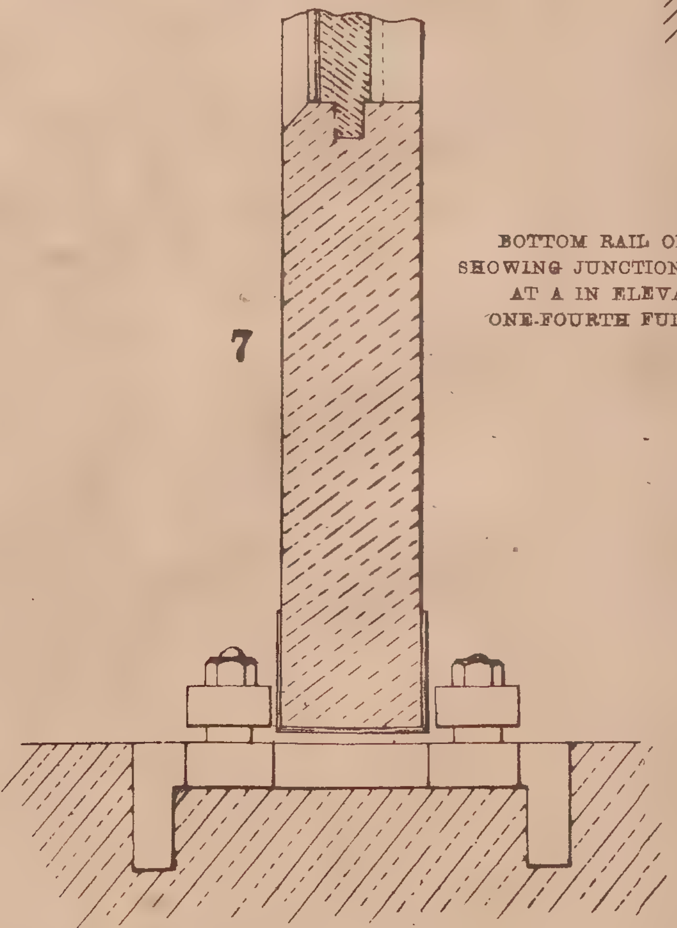


6

FRONT ELEVATION OF PULLEY RAIL AND STRAP. ONE-FOURTH FULL SIZE



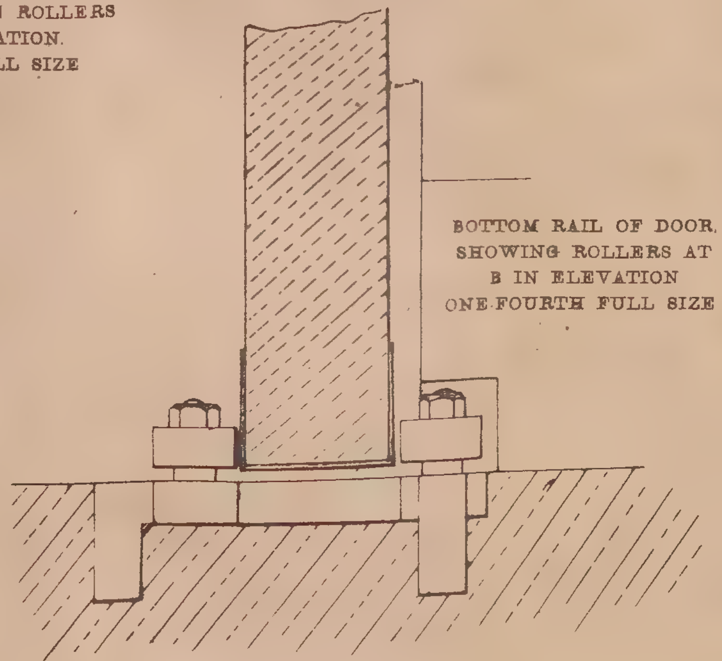
8



7

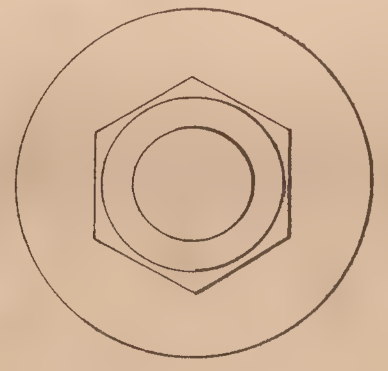
BOTTOM RAIL OF DOOR, SHOWING JUNCTION ROLLERS AT A IN ELEVATION. ONE-FOURTH FULL SIZE

9

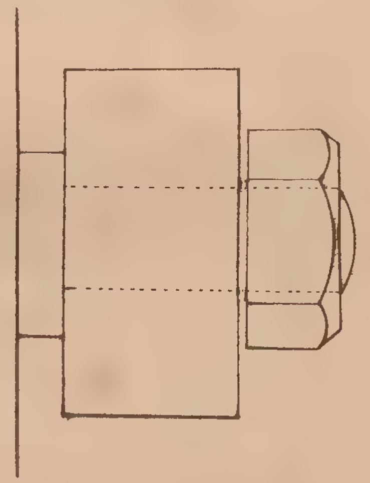


BOTTOM RAIL OF DOOR, SHOWING ROLLERS AT B IN ELEVATION ONE FOURTH FULL SIZE

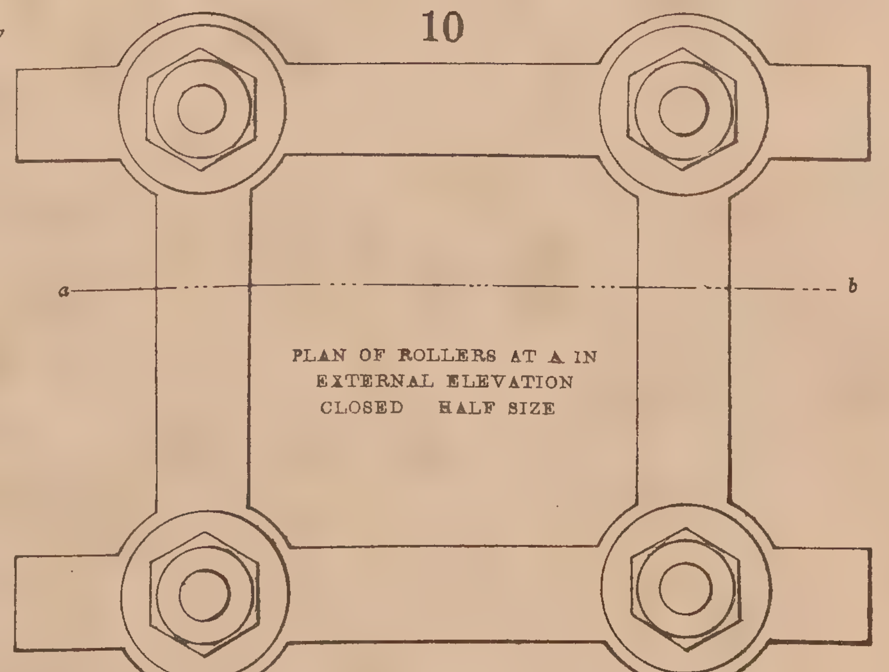
PLAN OF ROLLER FULL SIZE 14



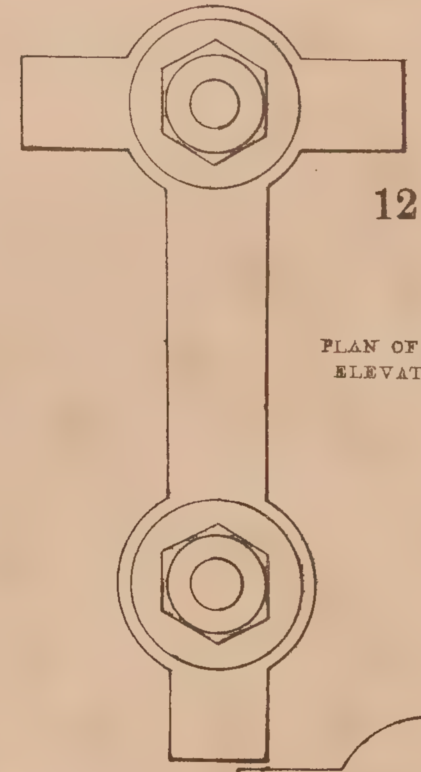
ELEVATION OF ROLLER FULL SIZE. 15



10



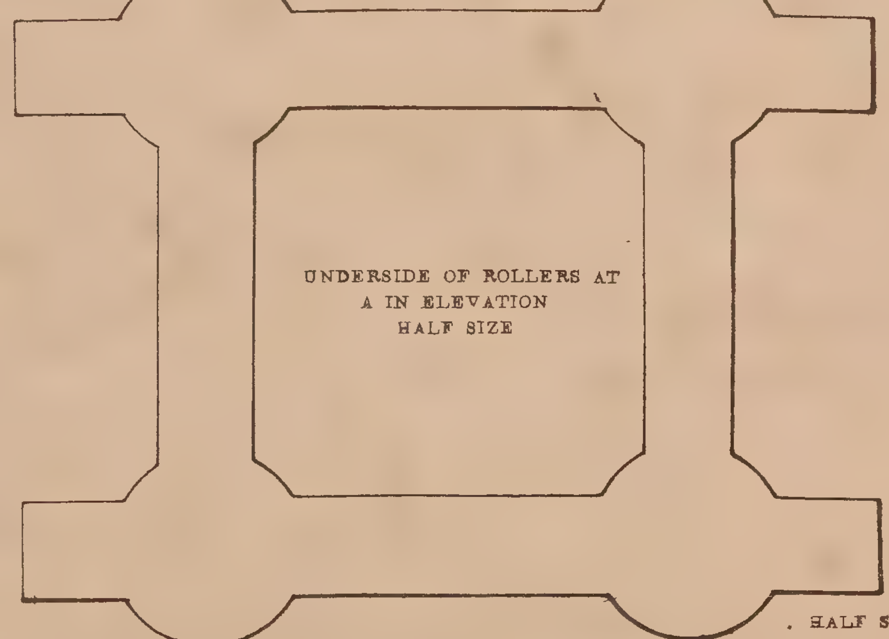
PLAN OF ROLLERS AT A IN EXTERNAL ELEVATION CLOSED HALF SIZE



12

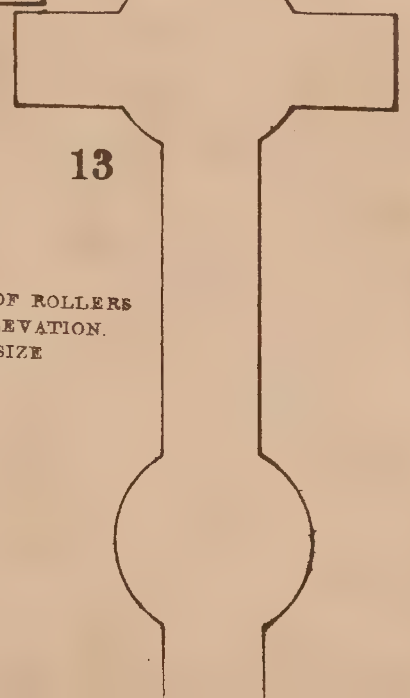
PLAN OF ROLLERS AT B IN ELEVATION. HALF SIZE

11



UNDERSIDE OF ROLLERS AT A IN ELEVATION HALF SIZE

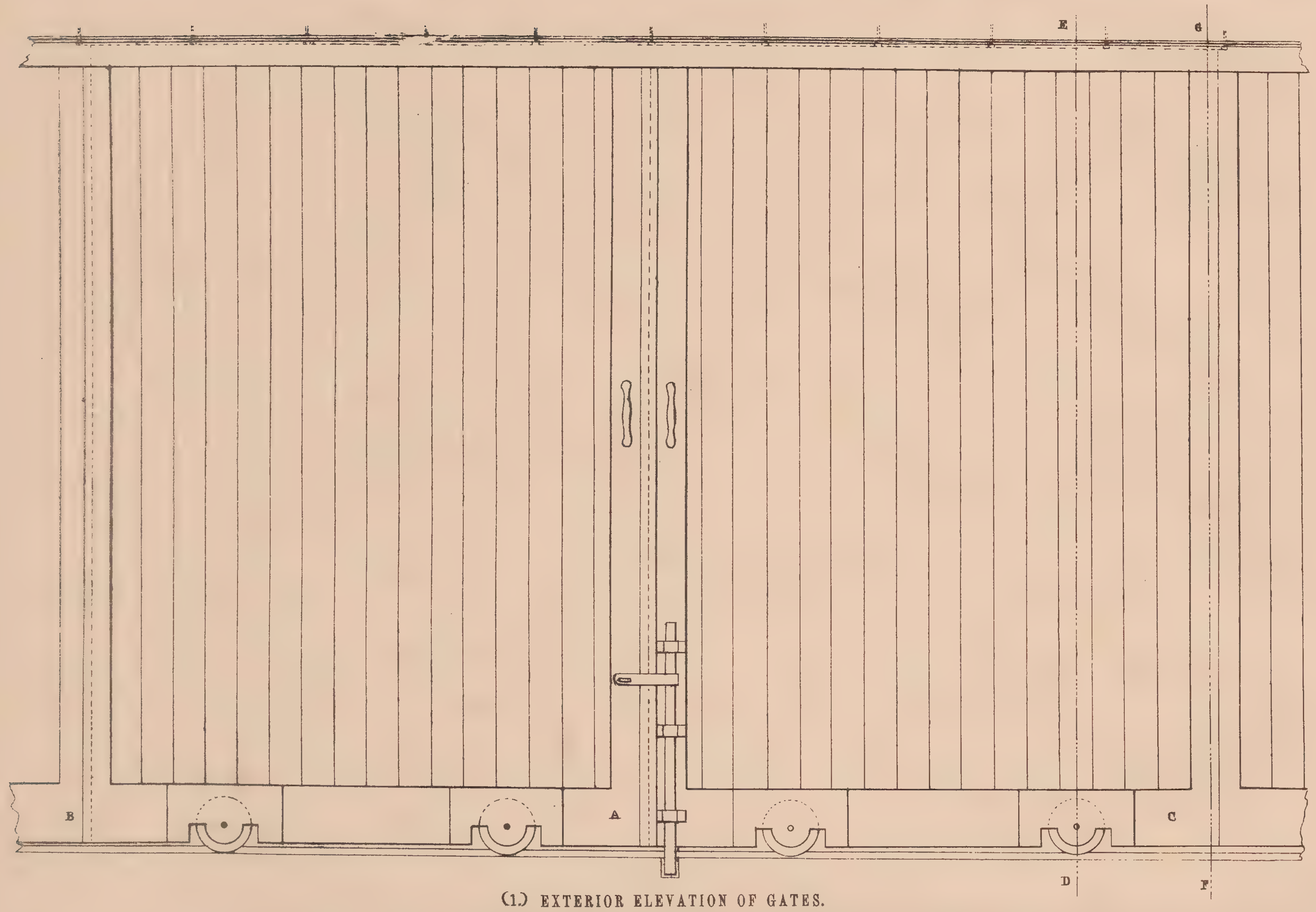
. HALF SIZE



13

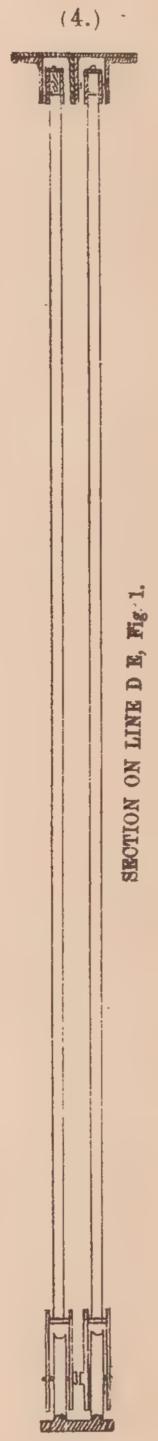
UNDERSIDE OF ROLLERS AT B IN ELEVATION. HALF SIZE

SLIDING DOORS OF CORRUGATED IRON FOR GRANARIES, WAREHOUSES, &c.



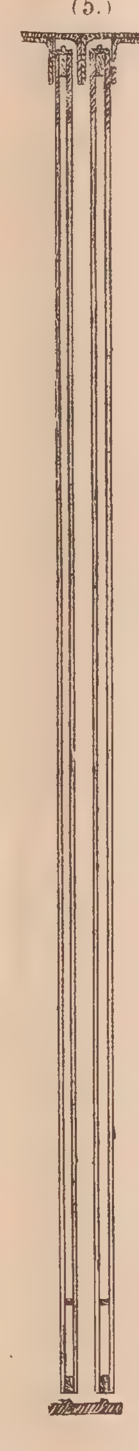
(1.) EXTERIOR ELEVATION OF GATES.

(4.)

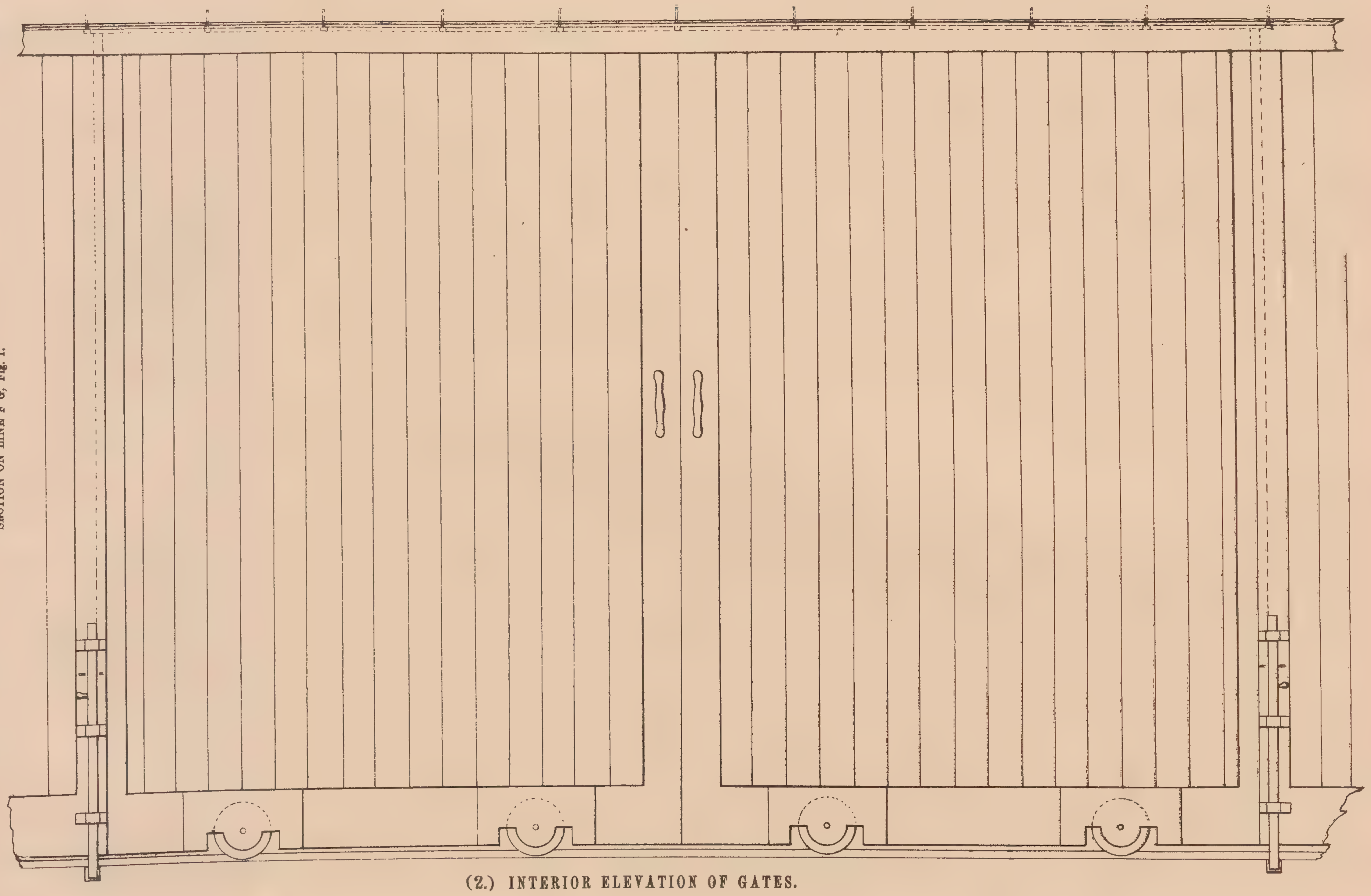


SECTION ON LINE D E, Fig. 1.

(5.)

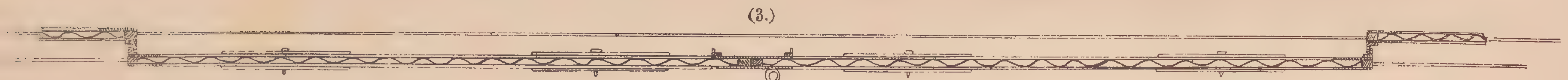


SECTION ON LINE F G, Fig. 1.

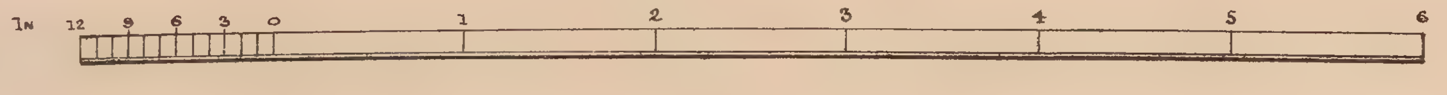


(2.) INTERIOR ELEVATION OF GATES.

(3.)

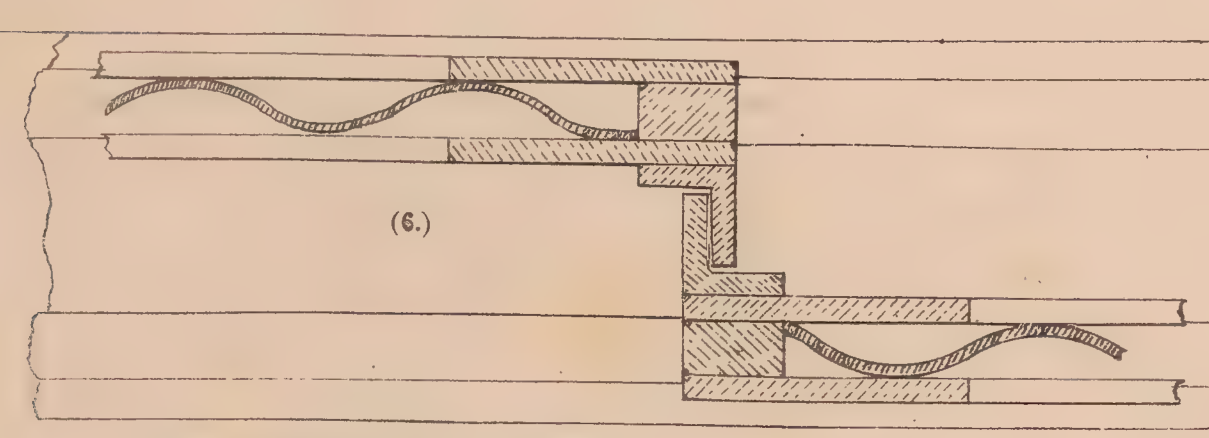


PLAN OF GATES.


In
12
9
6
3
0
1
2
3
4
5
6 Ft

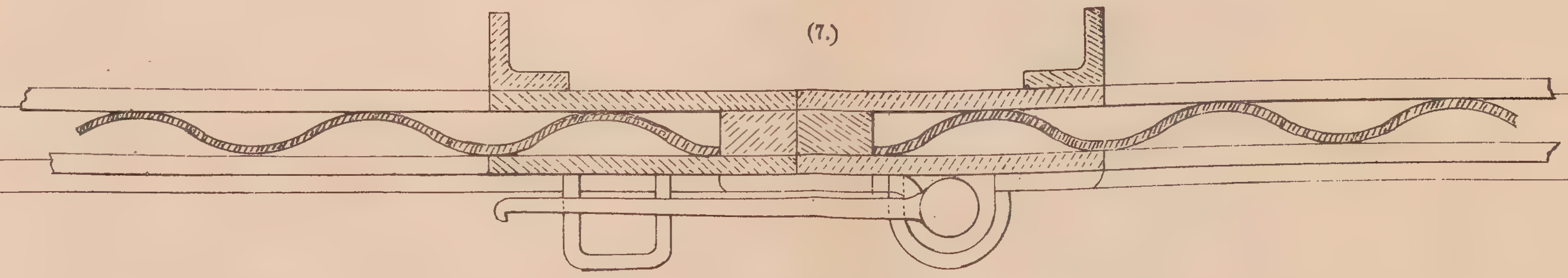
SCALE FOR Figs. 1, 2, 3, 4, and 5.

(6.)



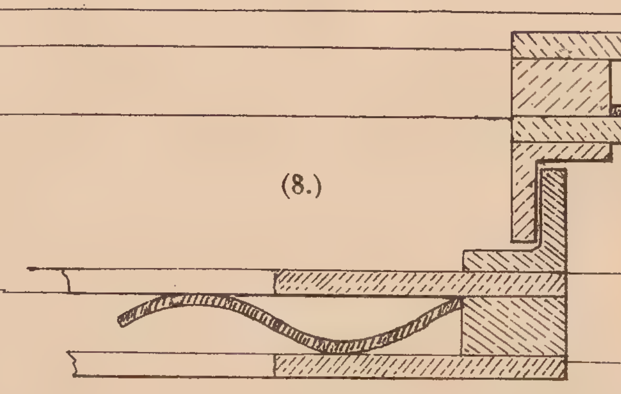
PLAN AT PART B, Fig. 1, HALF FULL SIZE.

(7.)



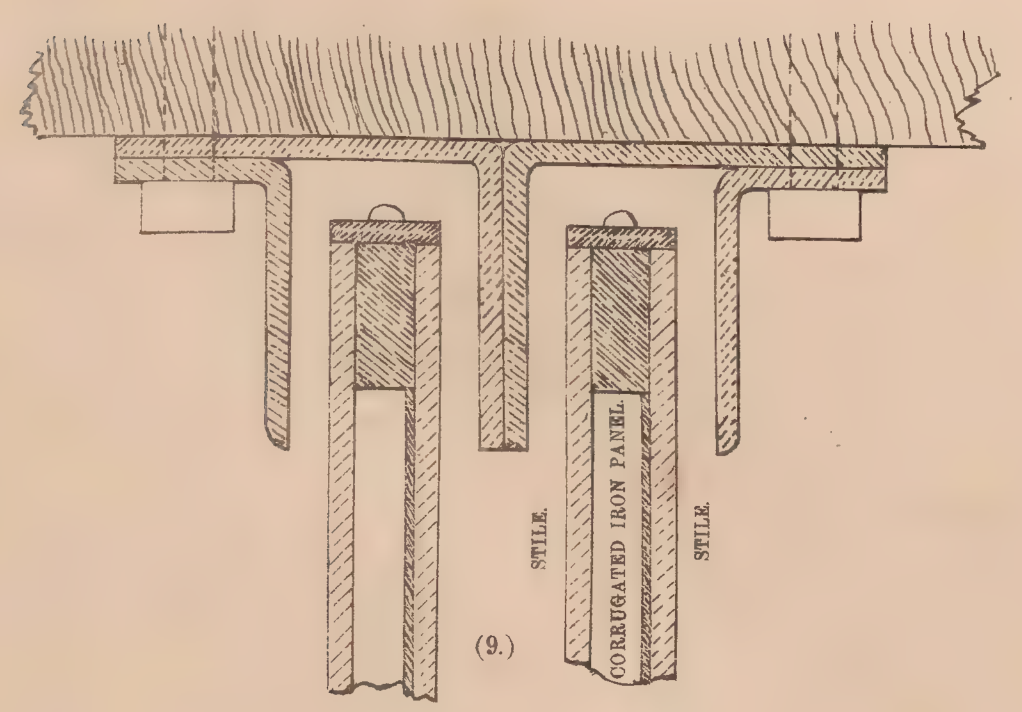
PLAN OF CLOSED STILES AT A, Fig. 1, HALF FULL SIZE.

(8.)



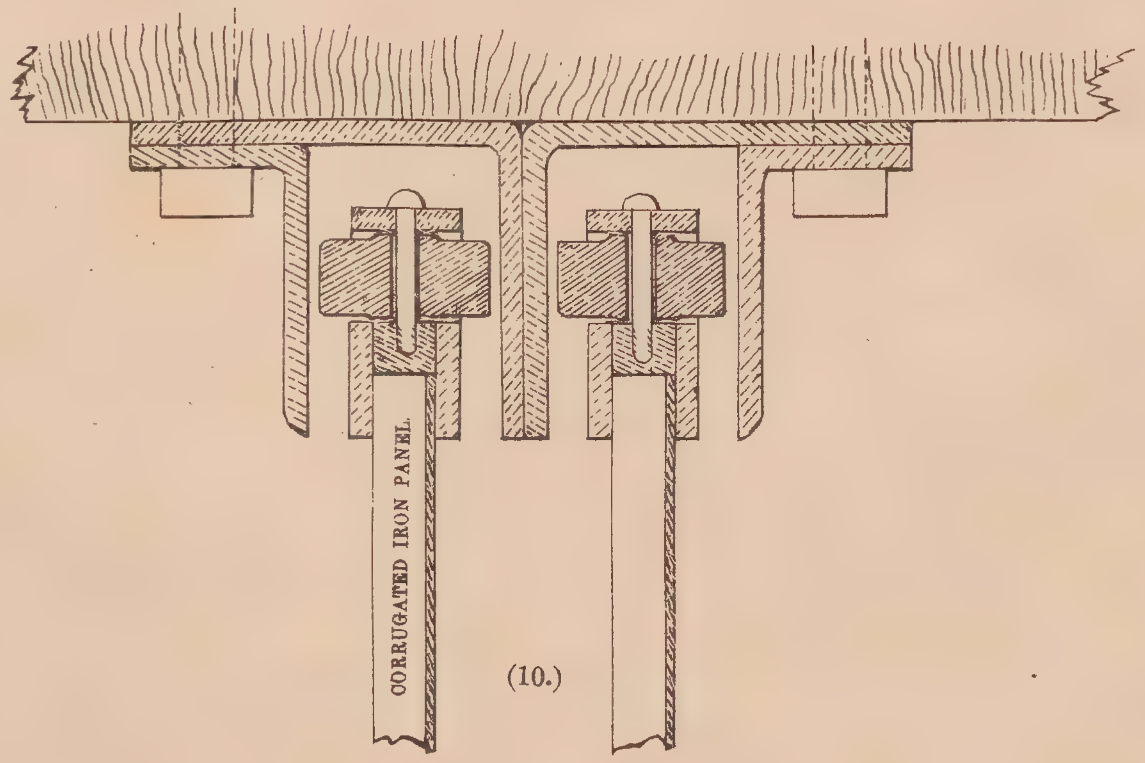
PLAN AT C, Fig. 1, HALF FULL SIZE.

(9.)


STILE
CORRUGATED IRON PANEL
STILE

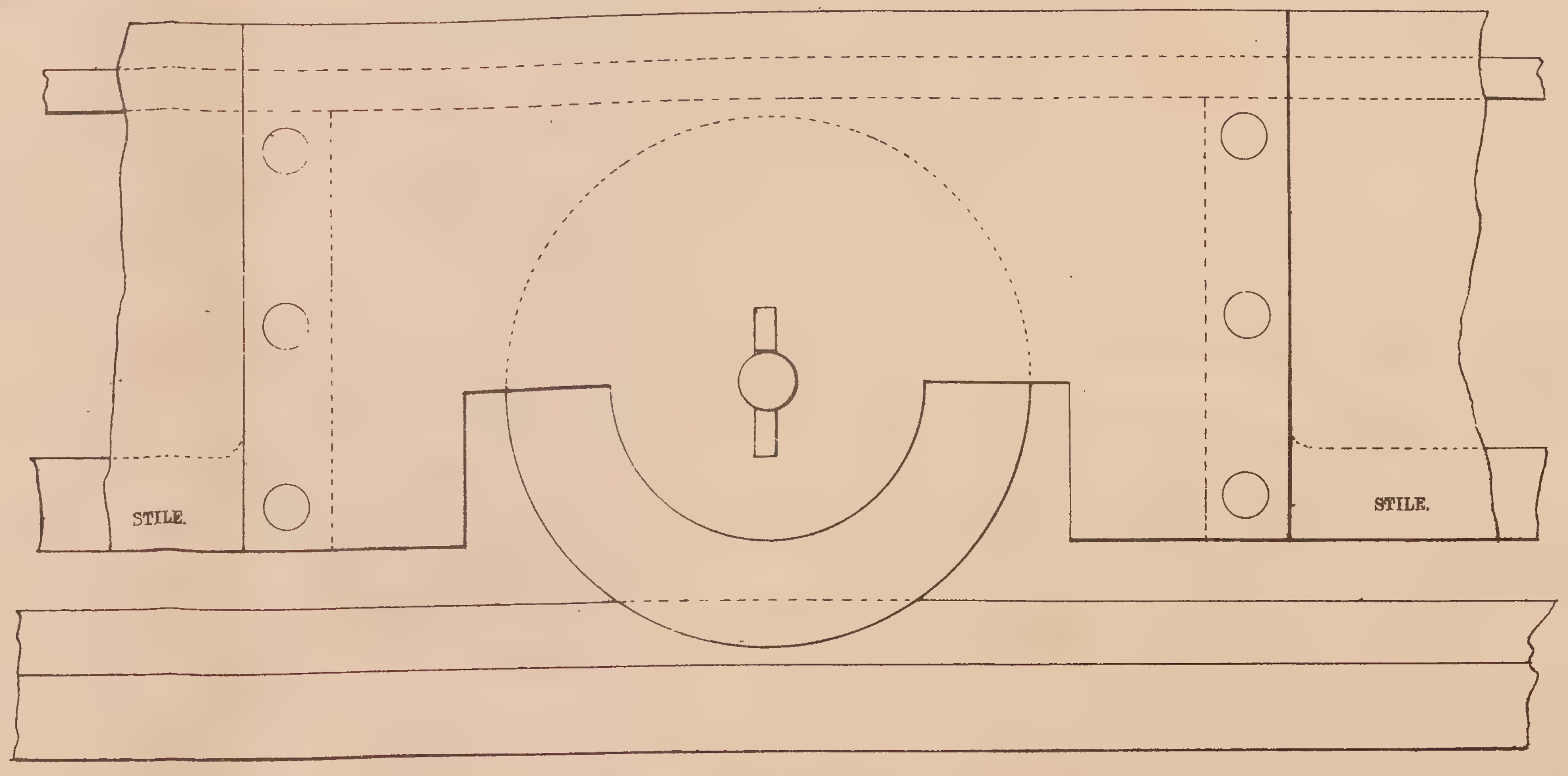
SECTION THROUGH HEADS OF DOORS AND STILES, HALF FULL SIZE.

(10.)


CORRUGATED IRON PANEL

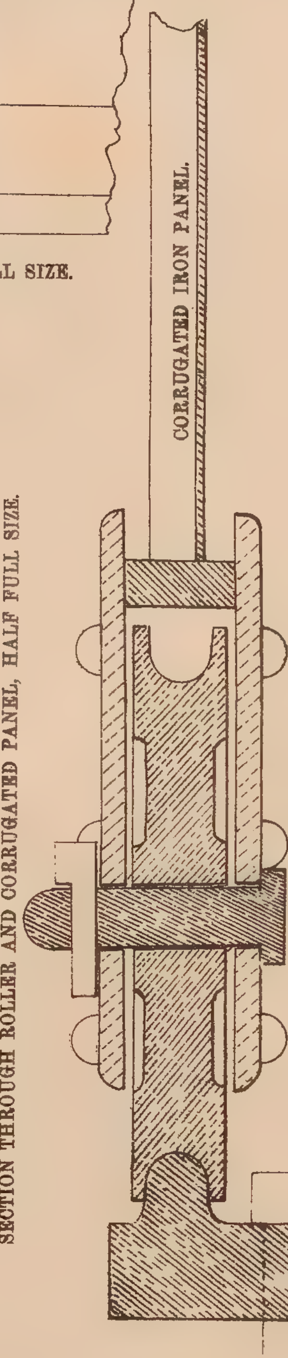
SECTION THROUGH HEADS OF DOORS AND RUNNERS, HALF FULL SIZE.

(11.)


STILE
STILE

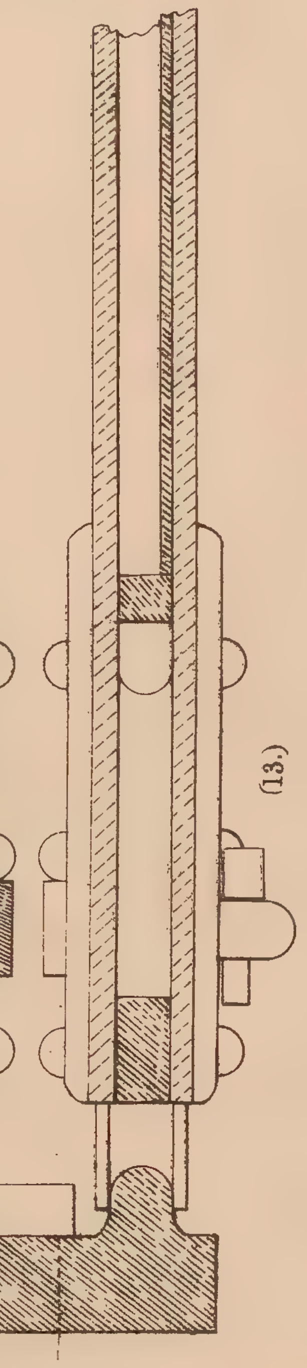
ELEVATION OF ROLLER PLATE, HALF FULL SIZE.

(12.)


CORRUGATED IRON PANEL
CAST-IRON RAIL

SECTION THROUGH ROLLER AND CORRUGATED PANEL, HALF FULL SIZE.

(13.)

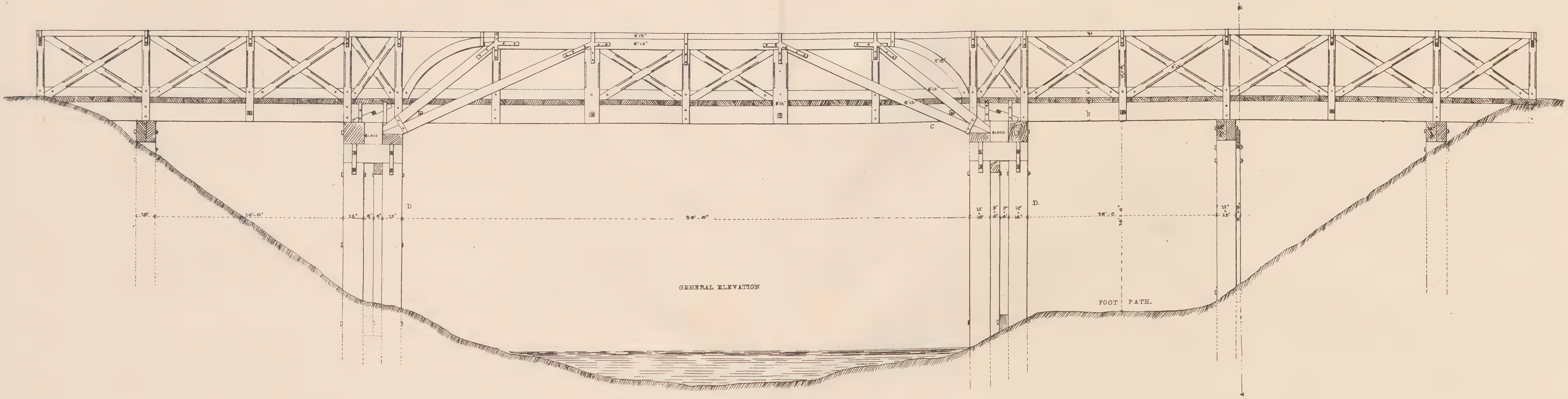


SECTION THROUGH LOWER PART OF DOOR STILES, HALF FULL SIZE.

A FULLARTON & Cº LONDON AND EDINBURGH.

TIMBER BRIDGE.

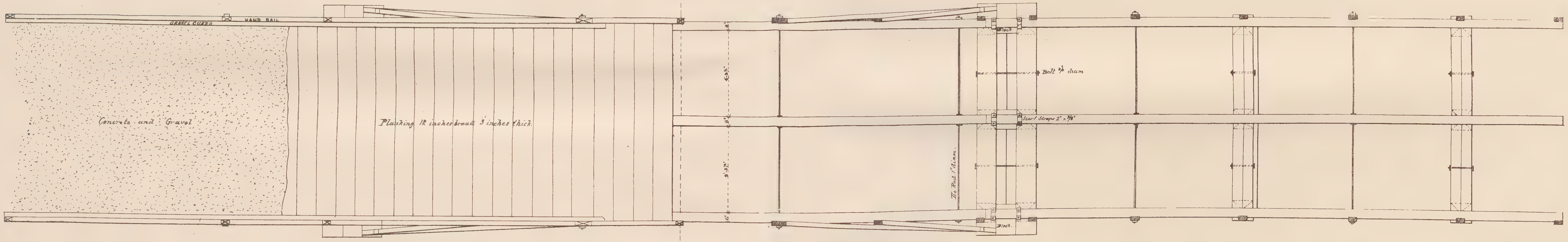
PLATE XLVIII.



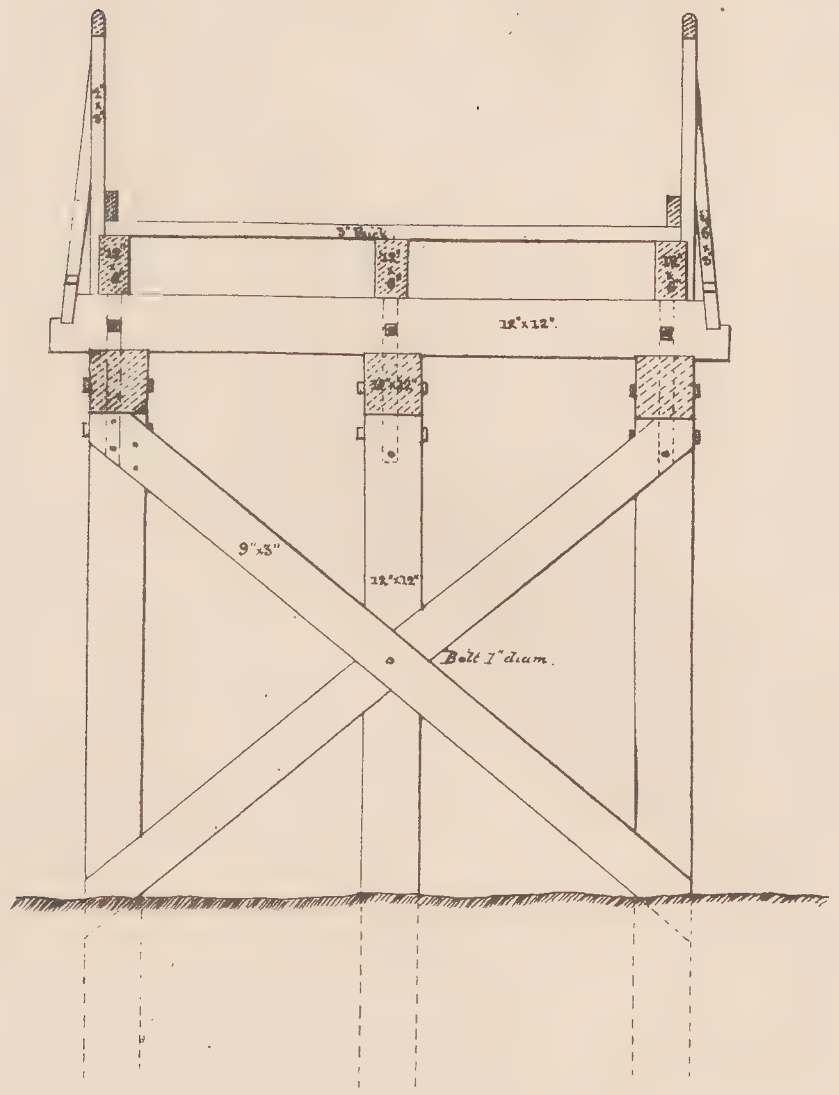
GENERAL ELEVATION
FOOT PATH.
BLOCK
C
D
D.
10'-0"
30'-0"
24'-0"

HALF PLAN WITH PLANKING.

HALF PLAN SHOWING TIMBERS.

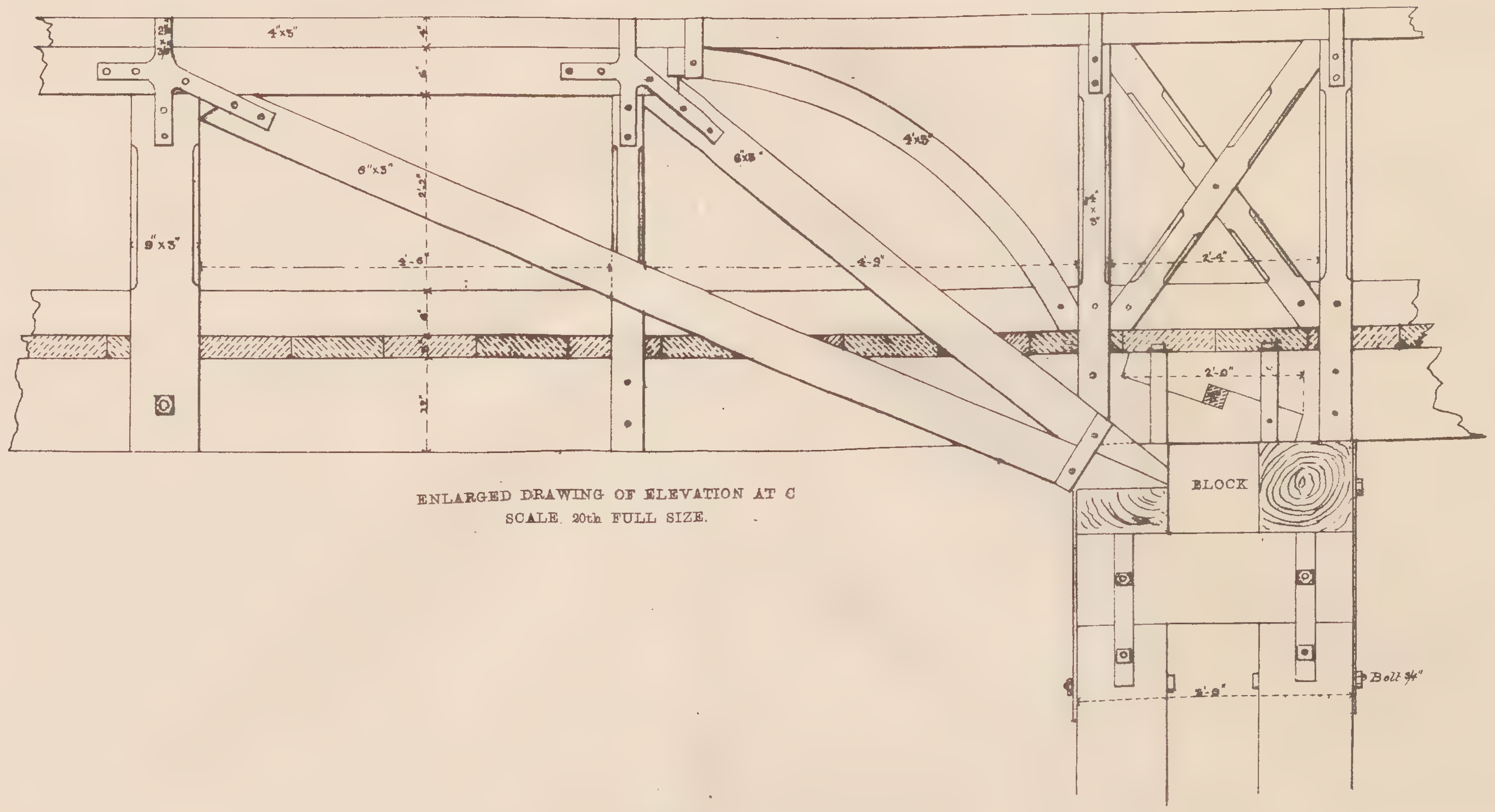


GRAVEL GUARD
HAND RAIL
Concrete and Gravel
Planking 12 inches broad 3 inches thick
Bolt ¾ diam
Scarf Straps 2" x ⅜"
Tie Rod 1" diam.
Block



12"x12"
9"x3"
Bolt 1" diam

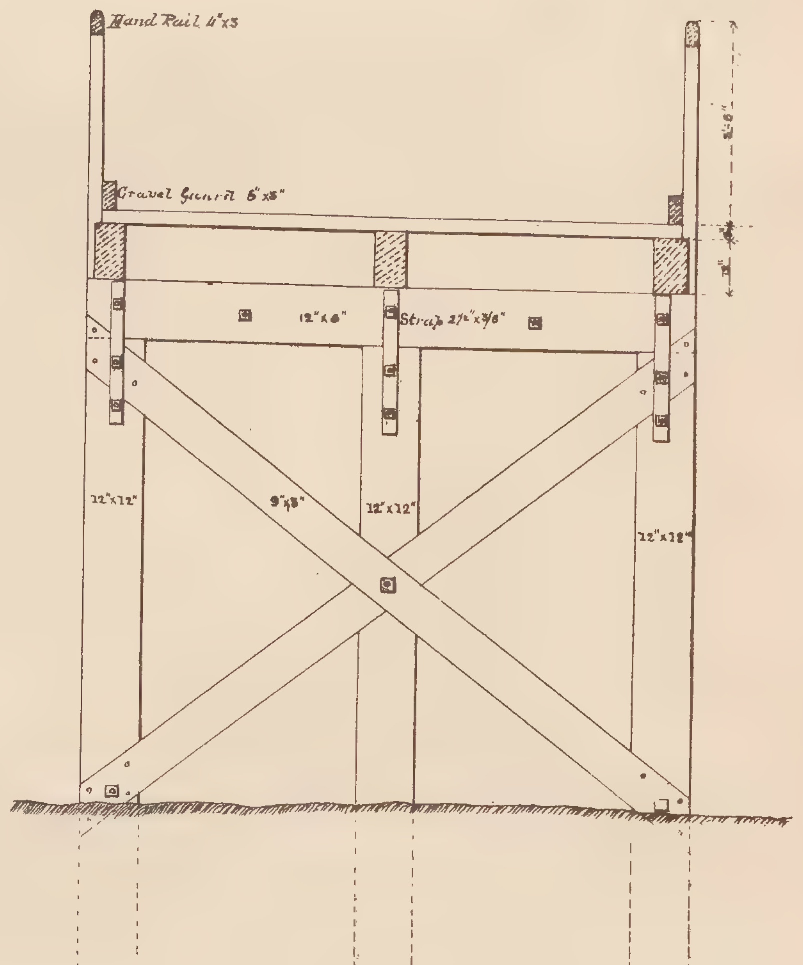
CROSS SECTION THROUGH PIER D



6"x3"
BLOCK
2'-0"
3'-9"
Bolt ¾"

ENLARGED DRAWING OF ELEVATION AT C
SCALE 20th FULL SIZE.

SCALE OF FEET TO GENERAL DRAWINGS.

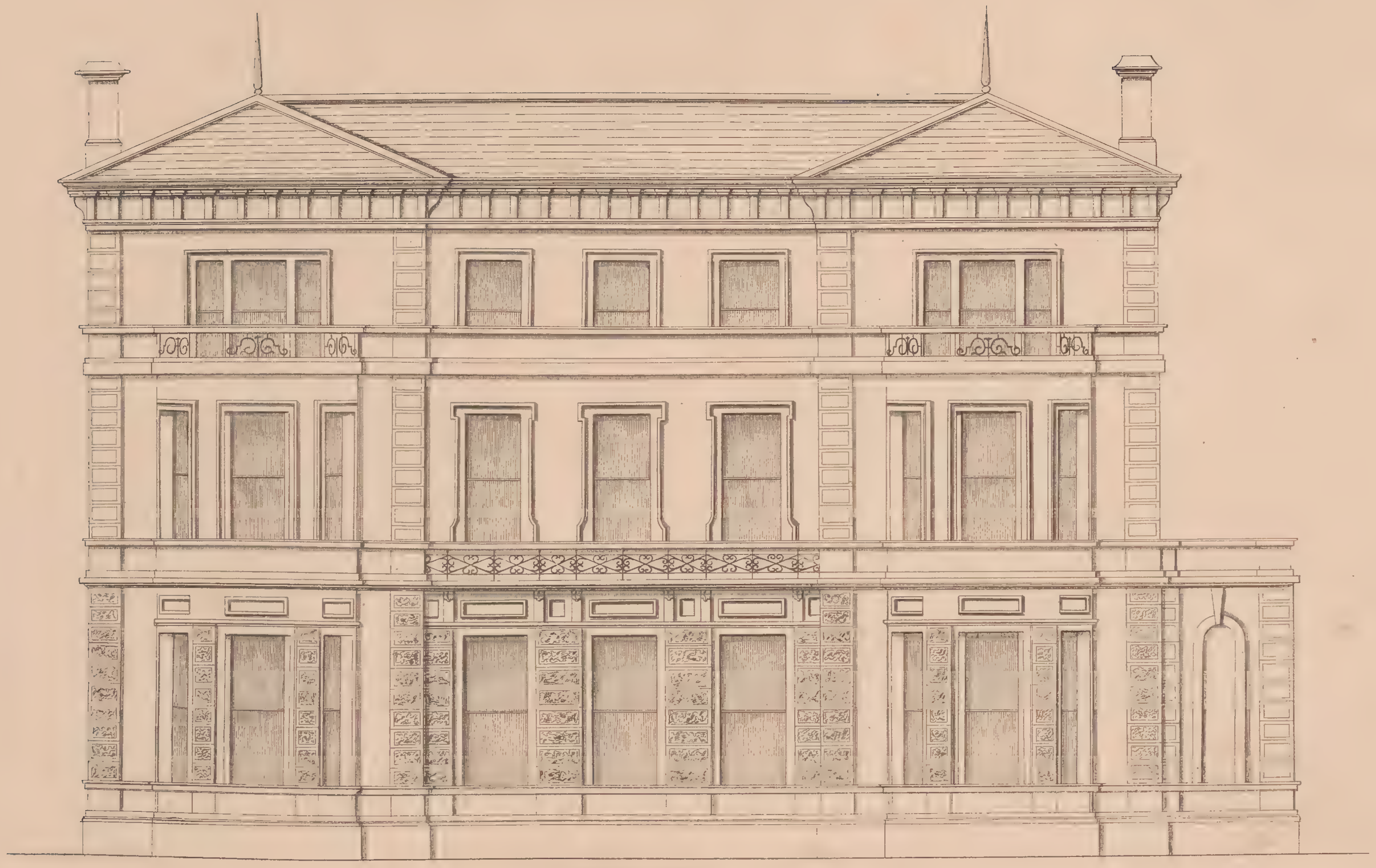


Hand Rail 6"x3
Gravel Guard 6"x2"
12"x6"
Strap 2½"x⅜"
12"x12"
9"x3"

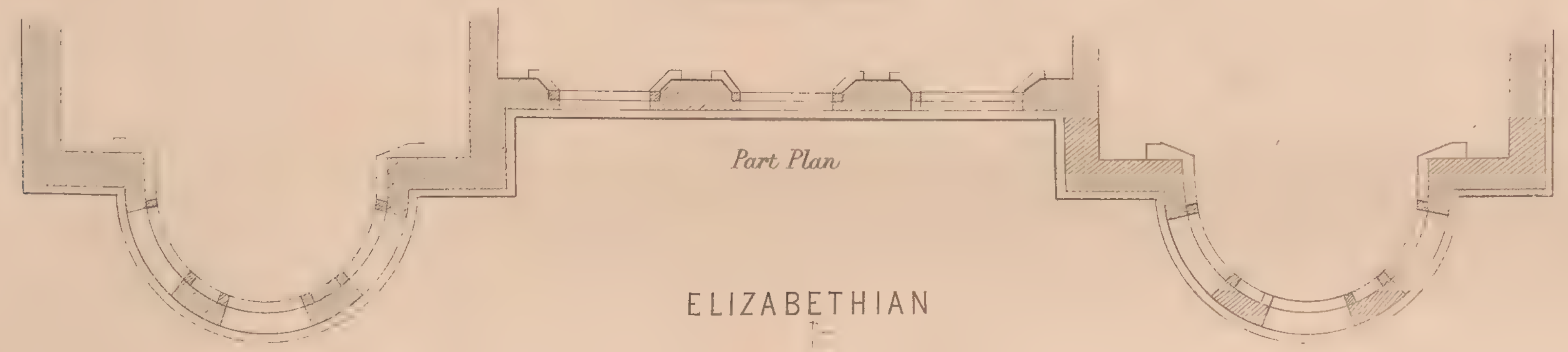
CROSS SECTION ON LINE A B

EXAMPLES OF DOMESTIC ARCHITECTURE.

ITALIAN

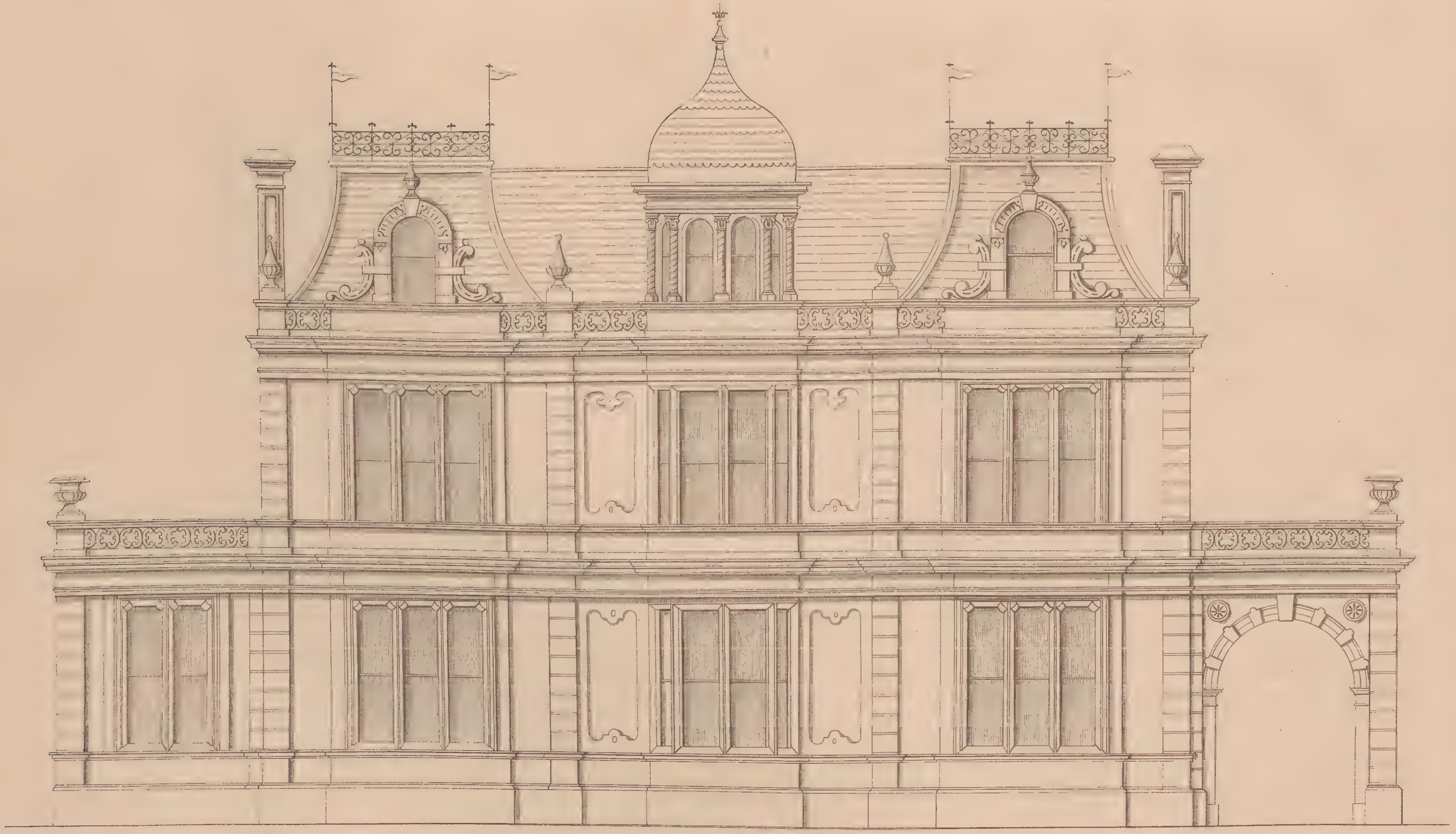


Elevation 1/8 Scale

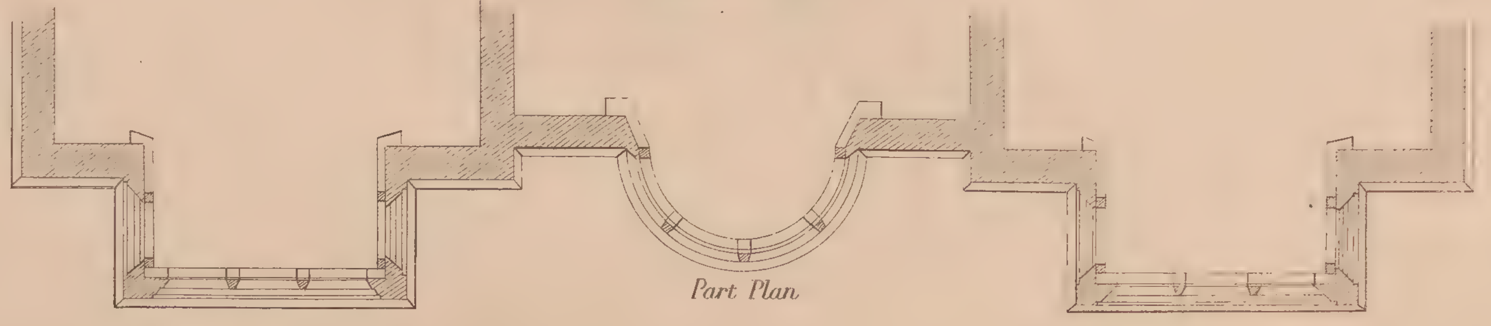


Part Plan

ELIZABETHIAN

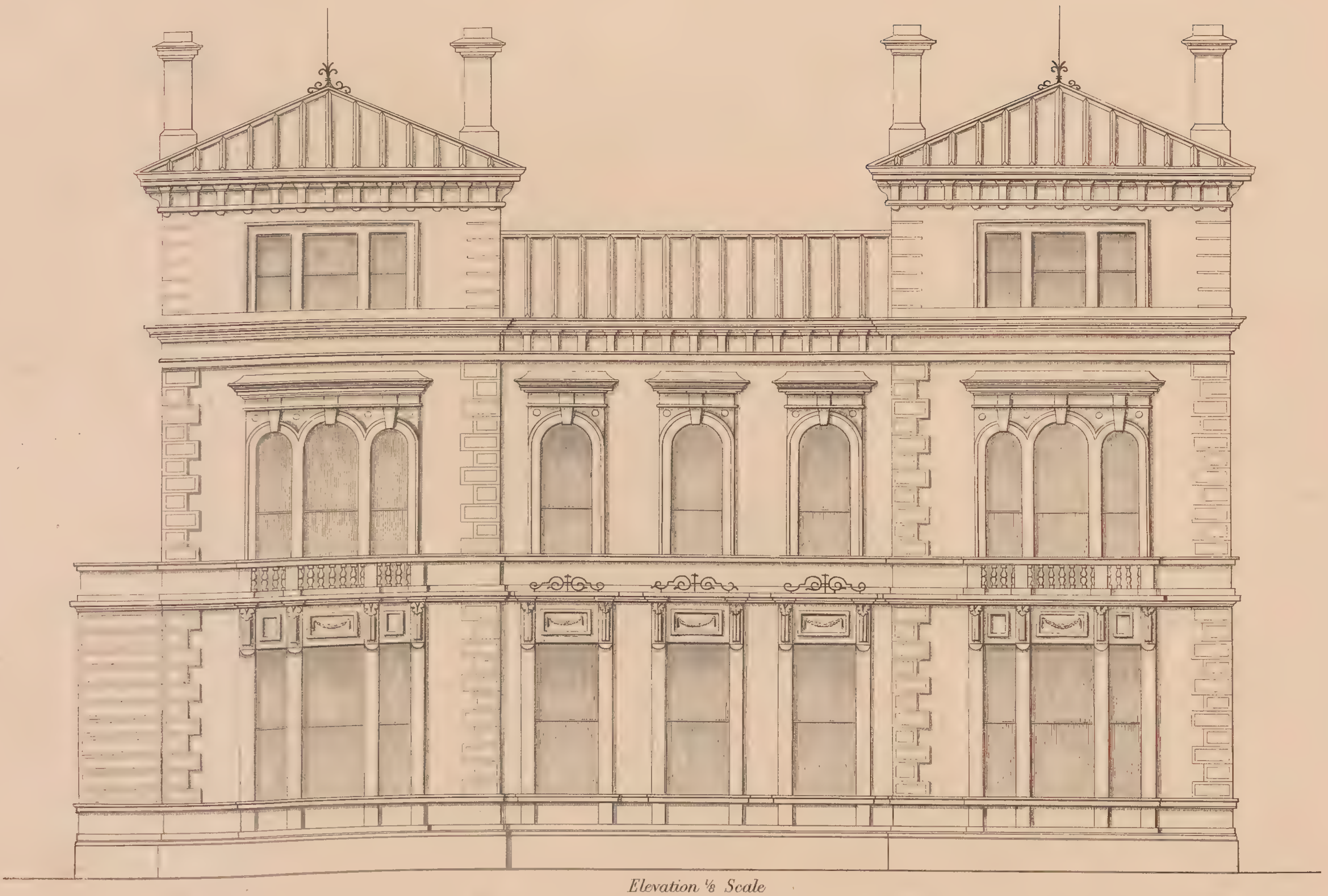


Elevation 1/8 Scale

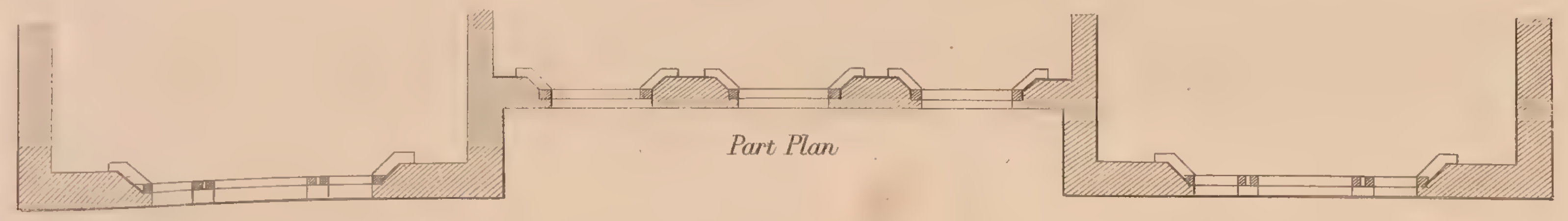


Part Plan

ITALIAN

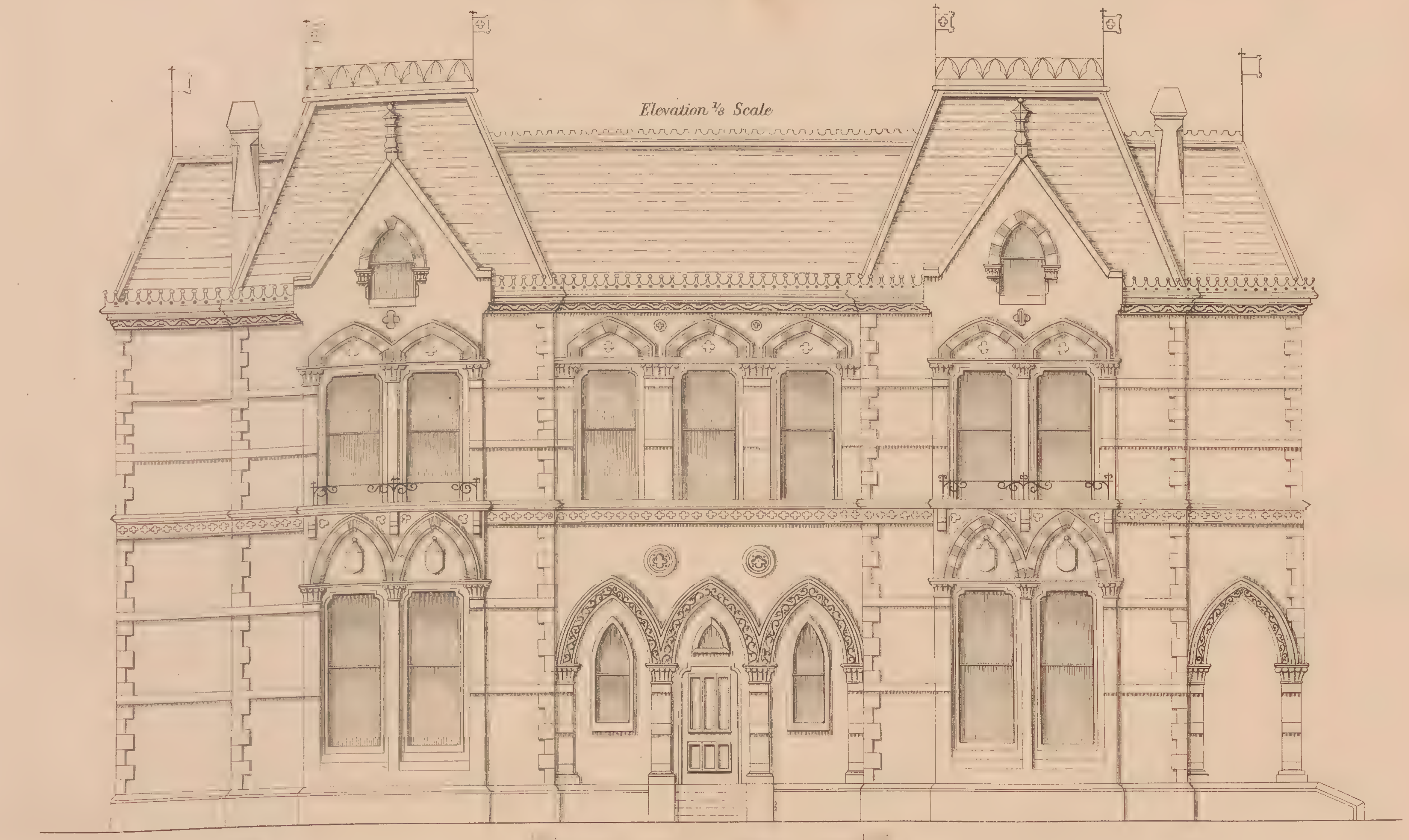


Elevation 1/8 Scale

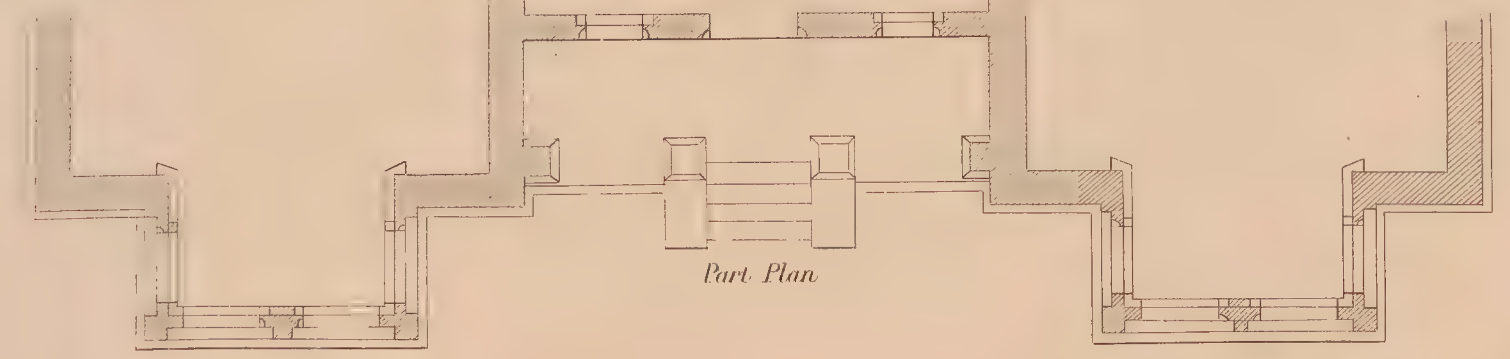


Part Plan

GOTHIC



Elevation 1/8 Scale



Part Plan

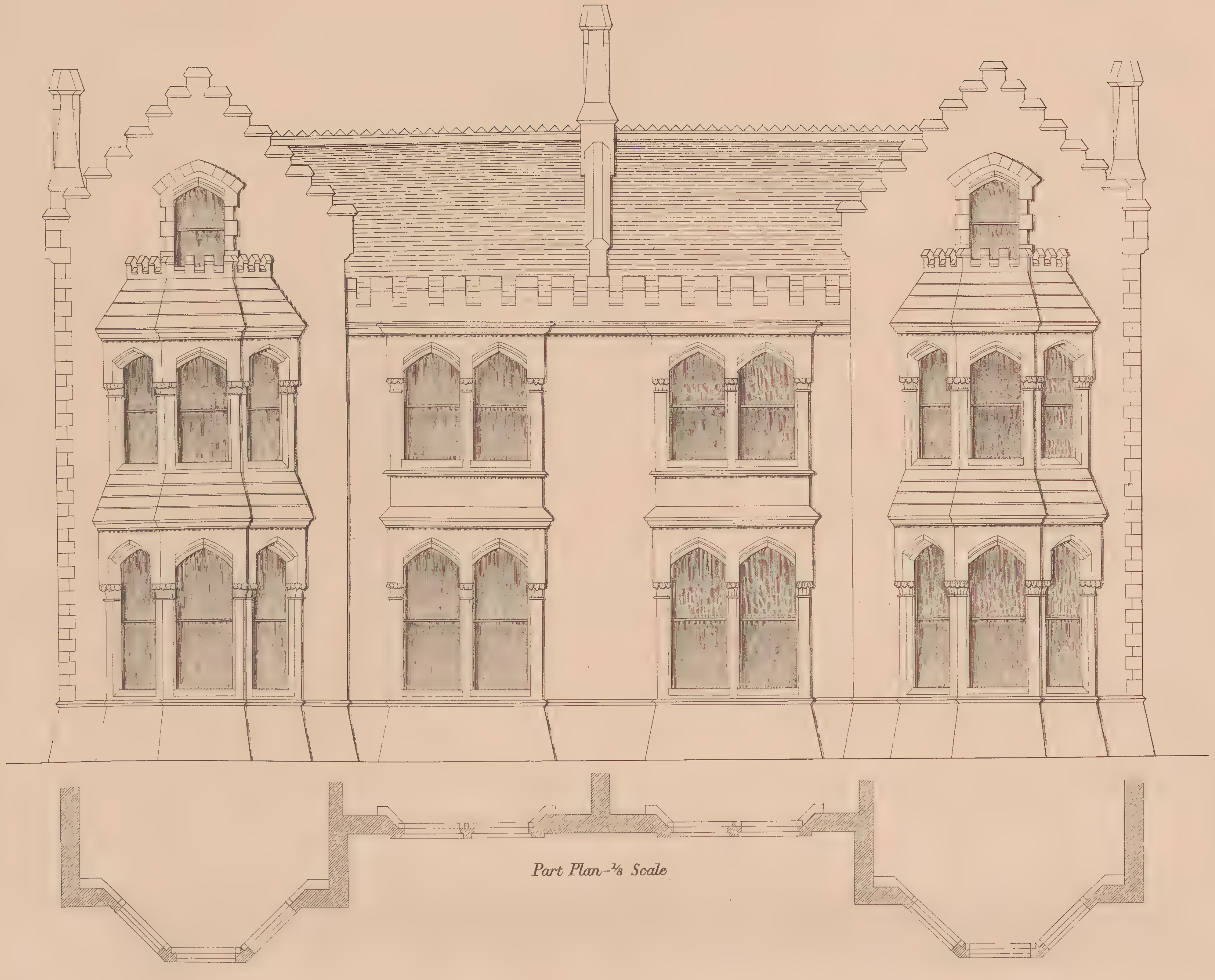
A. FULLARTON & CO. LONDON AND EDINBURGH.

SHEET B.

EXAMPLES OF DOMESTIC ARCHITECTURE.

Fig. 1

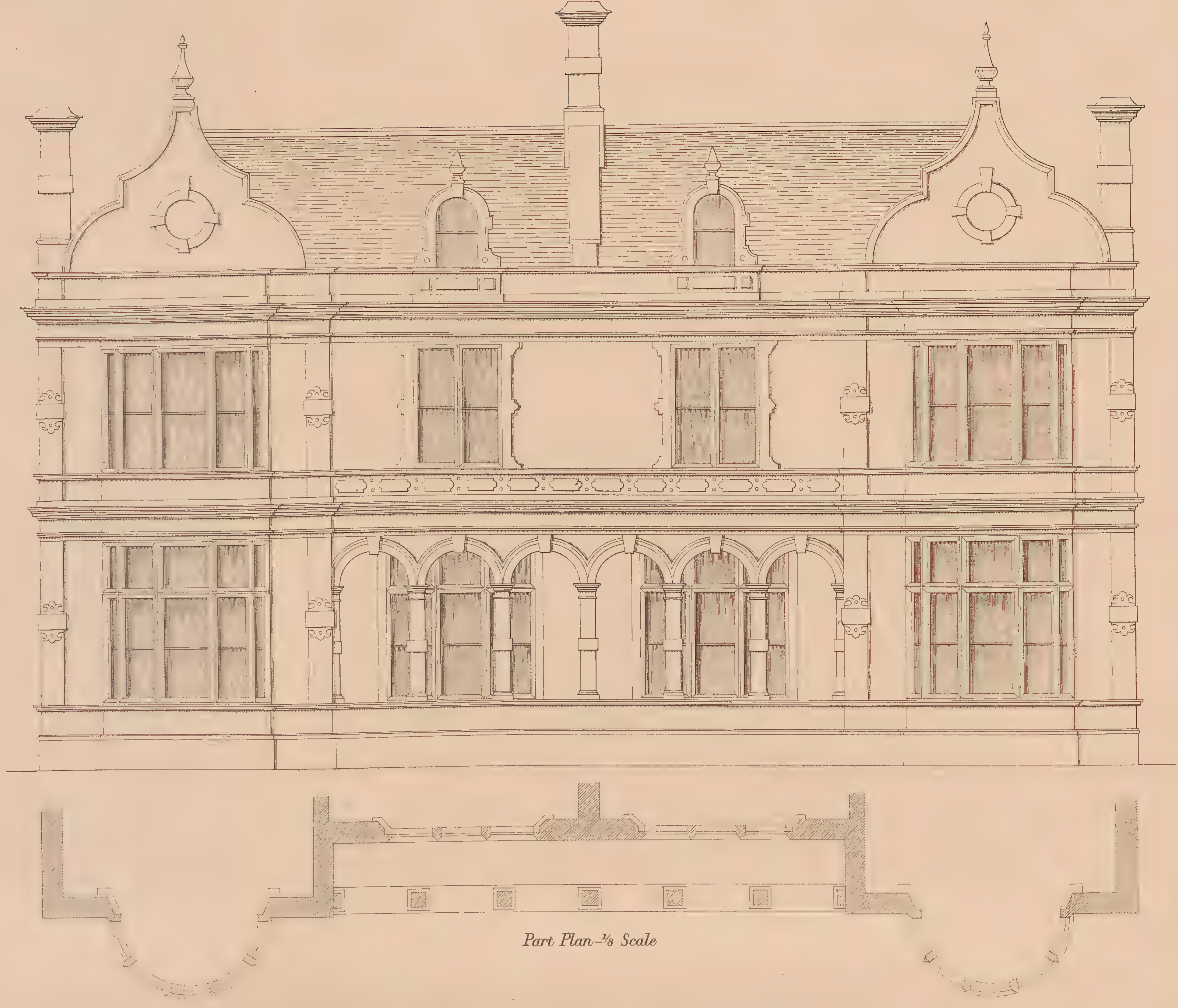
GOTHIC



Part Plan-1/8 Scale

Fig. 2

ELIZABETHIAN



Part Plan-1/8 Scale

Fig. 3.

GOTHIC

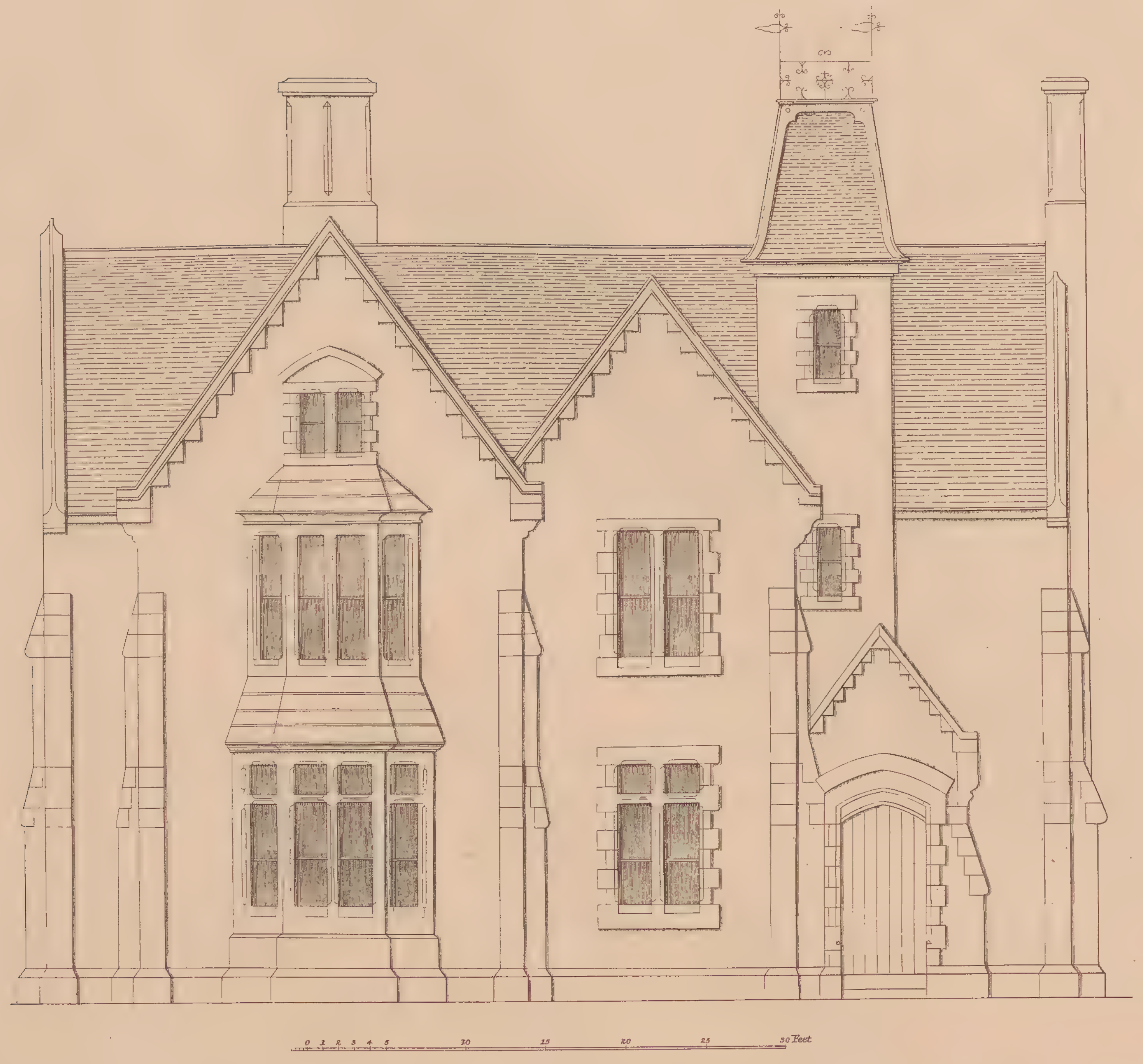
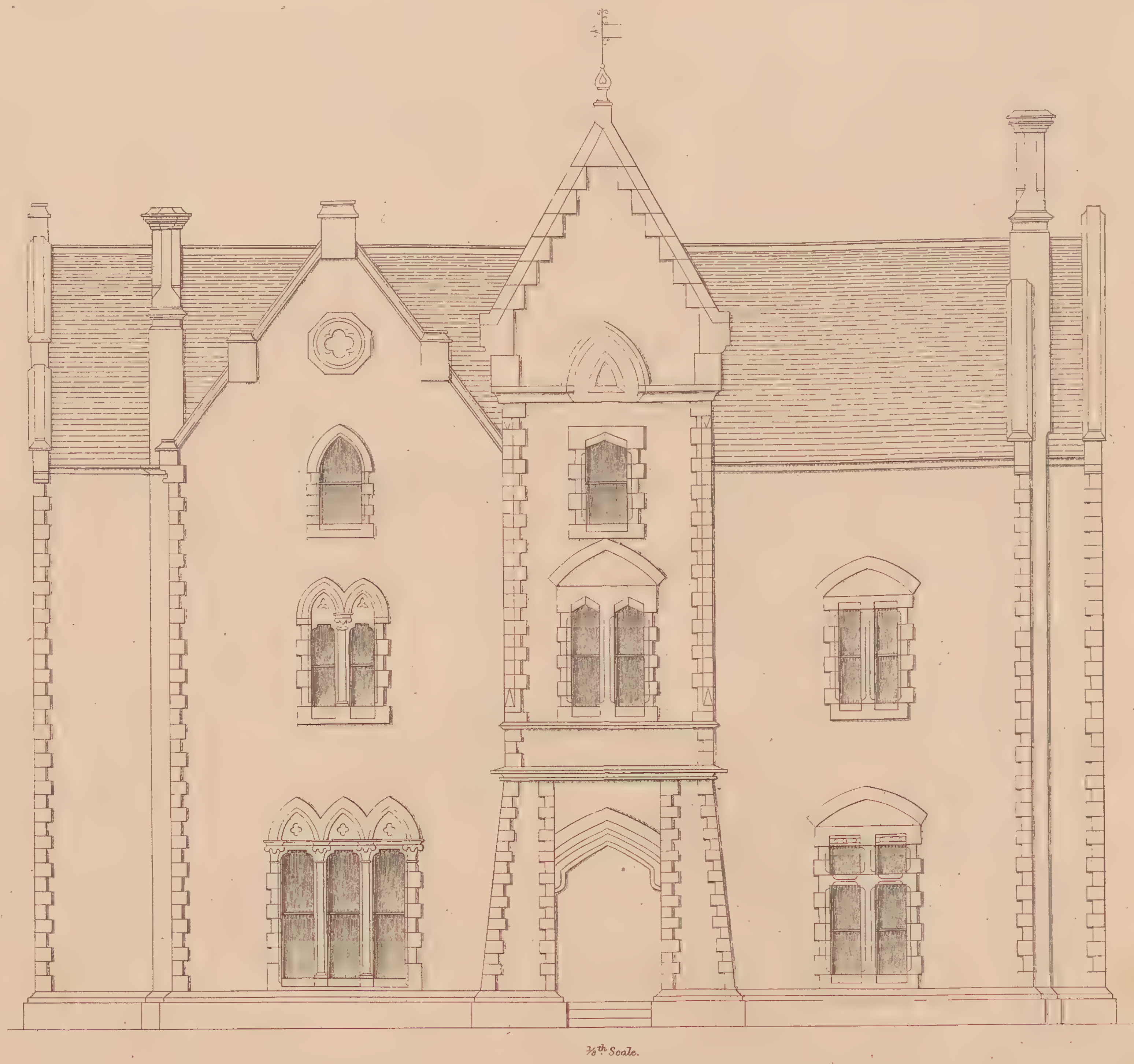


Fig. 4.

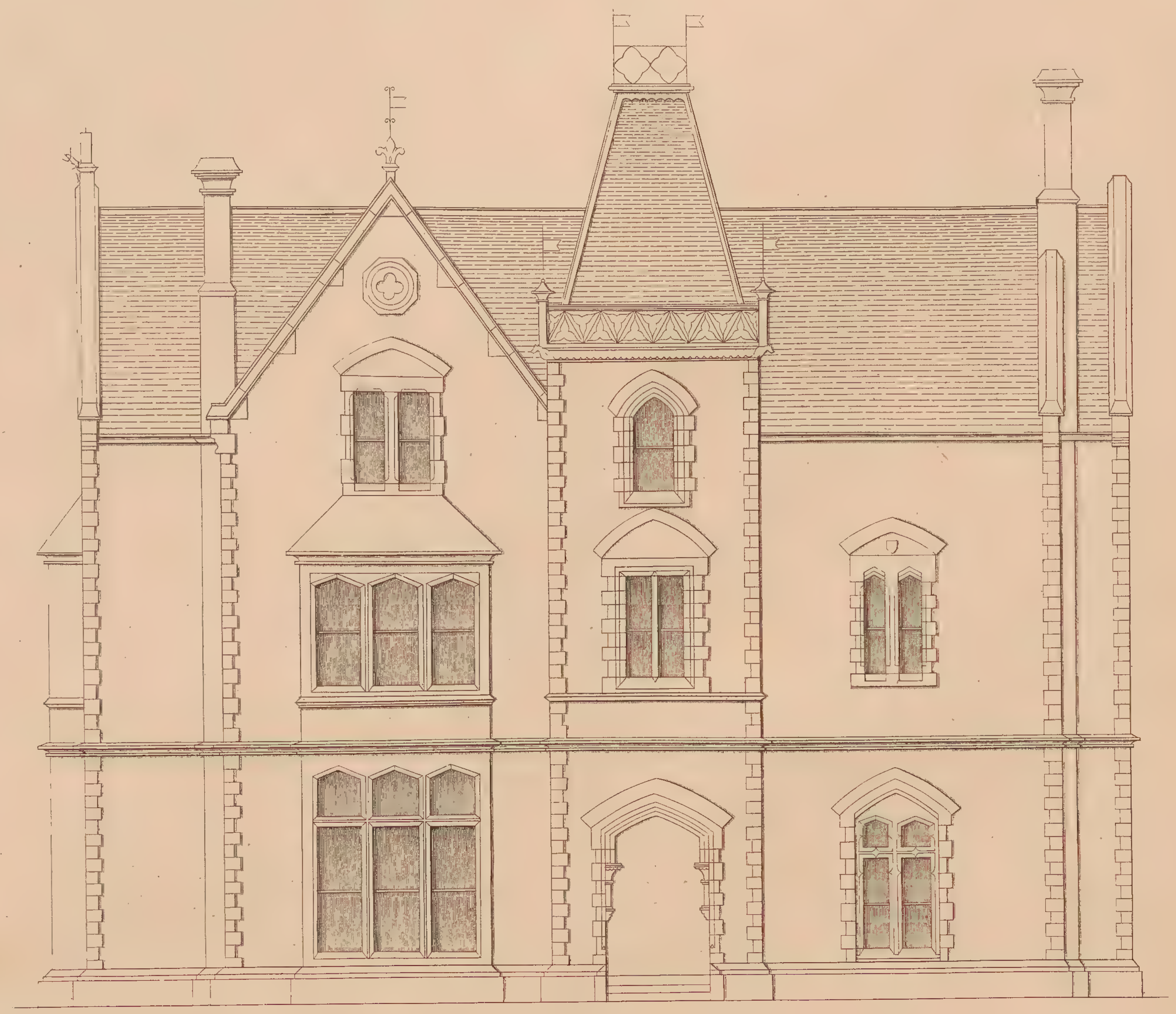
GOTHIC



1/8th Scale.

Fig. 5.

GOTHIC



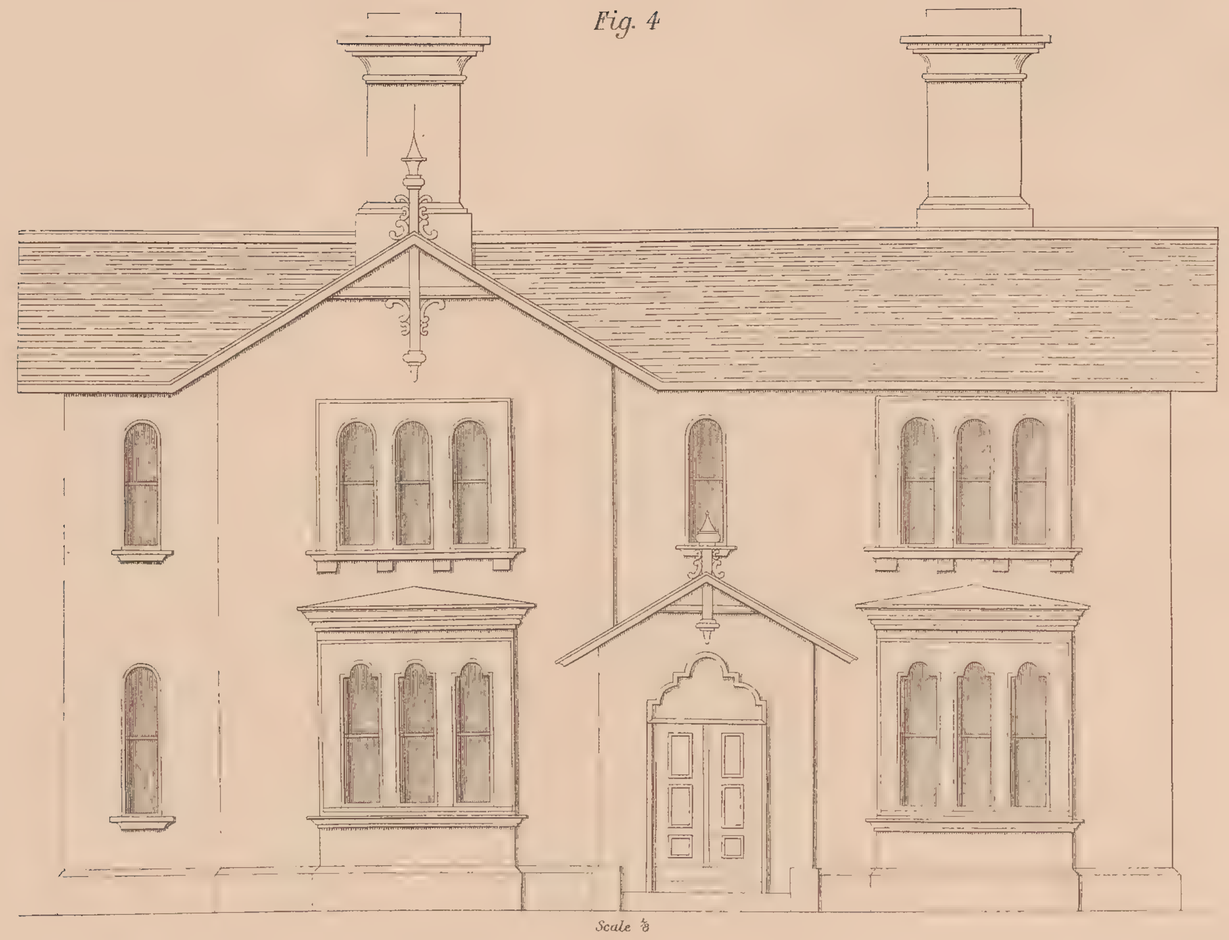
1/8th Scale.

Engraved by J. Bartholomew, Edinburgh.

A. FULLARTON & CO. LONDON AND EDINBURGH.

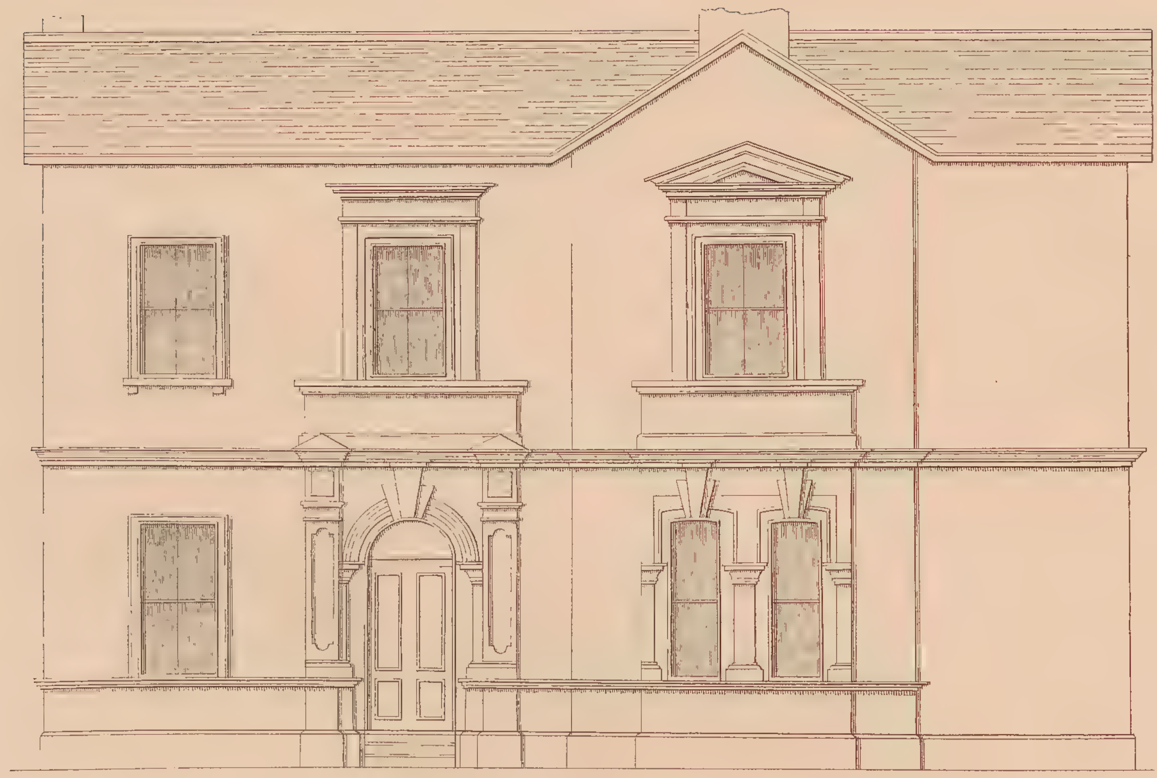
EXAMPLES OF
DOMESTIC ARCHITECTURE.
IN THE ITALIAN STYLE.

Fig. 4



Scale ⅛

Fig. 6



Scale ⅛

Fig. 2

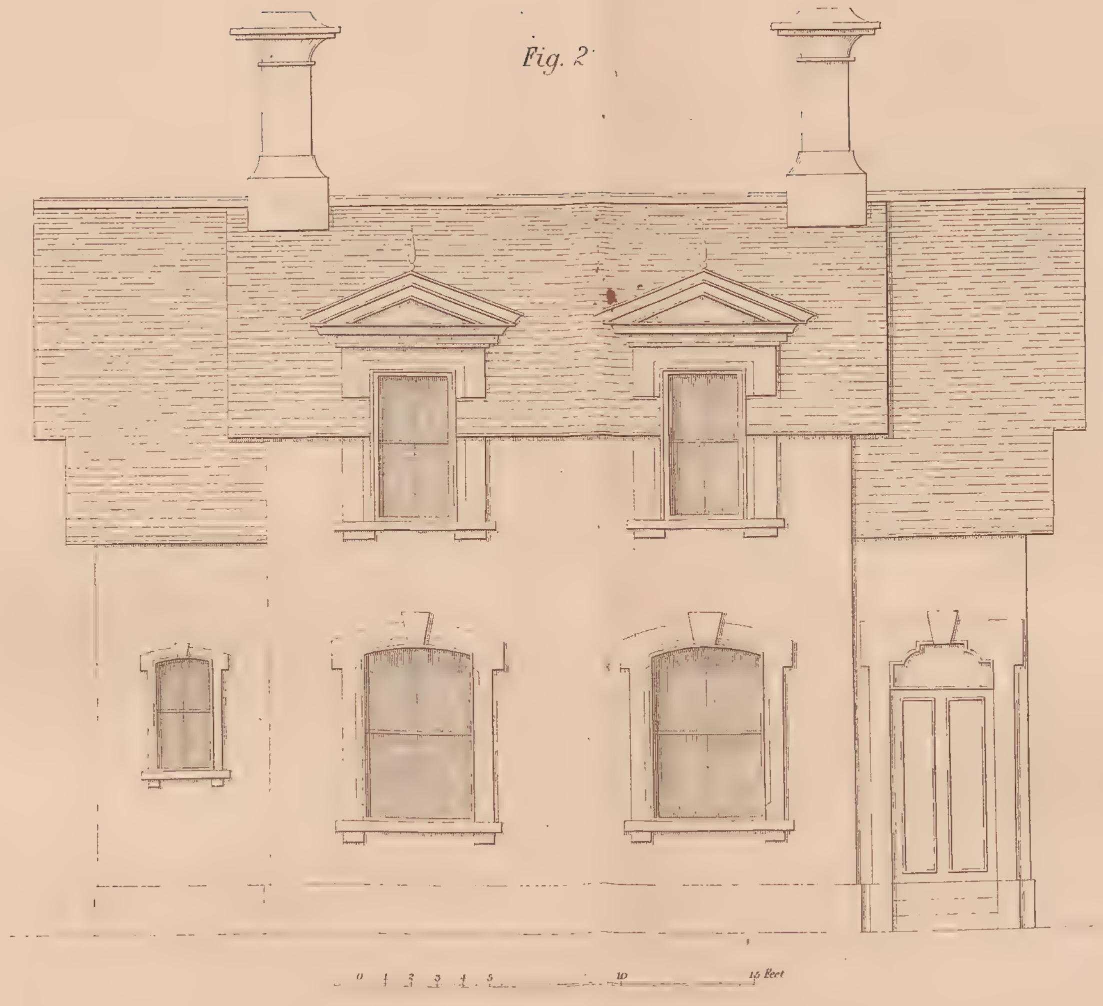

0 1 2 3 4 5 10 15 Feet

Fig. 1

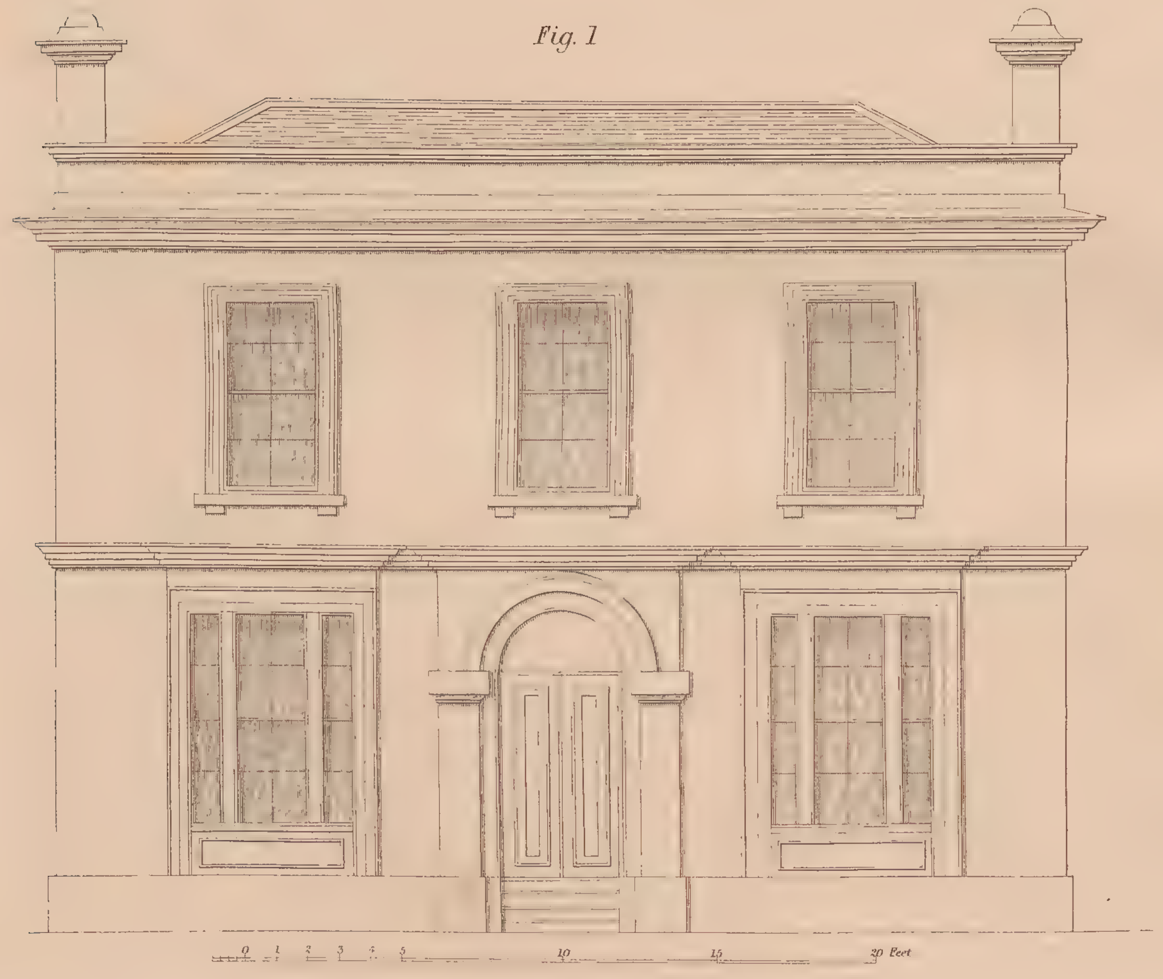
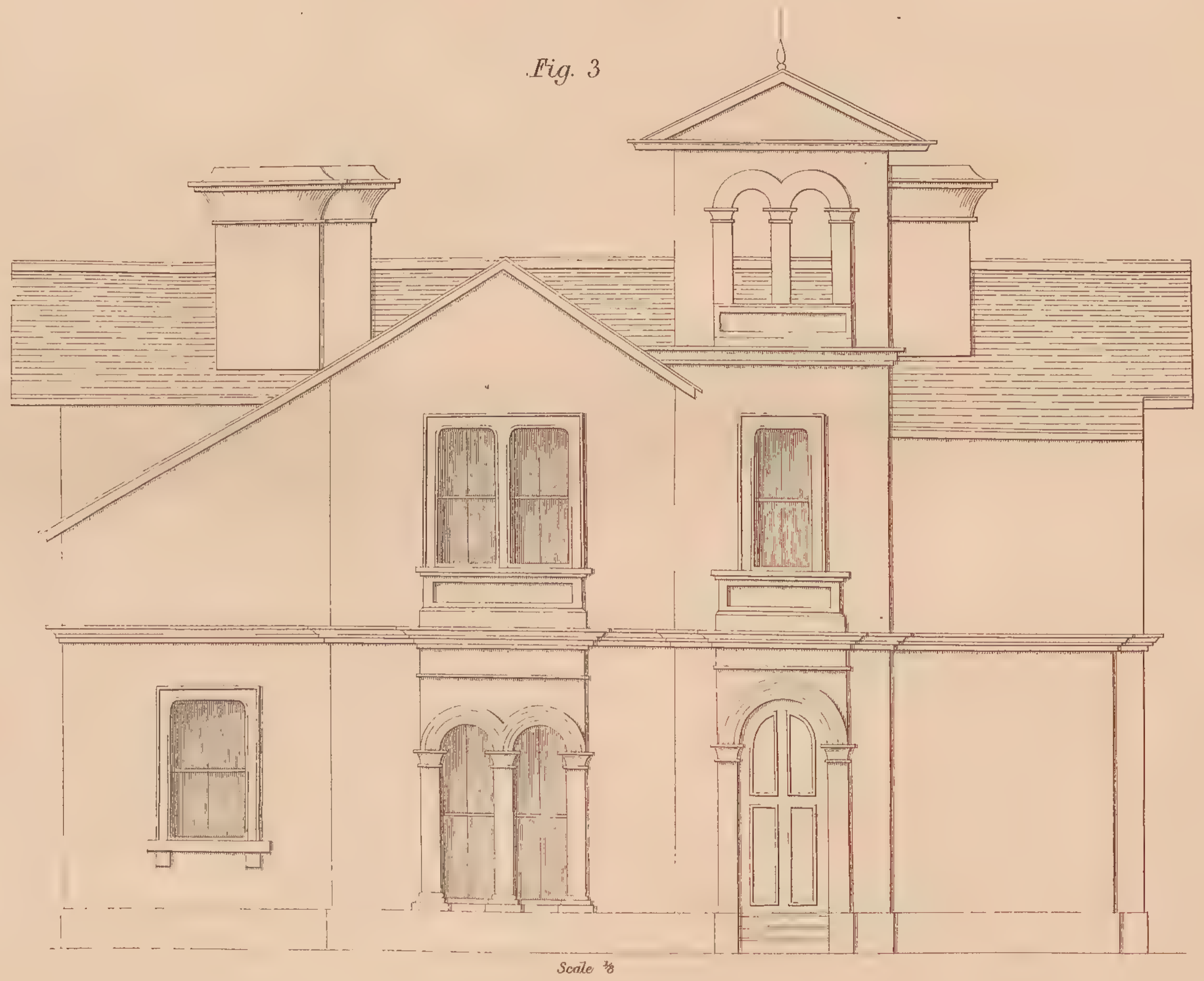

0 1 2 3 4 5 10 15 20 Feet

Fig. 3



Scale ⅛

Fig. 5

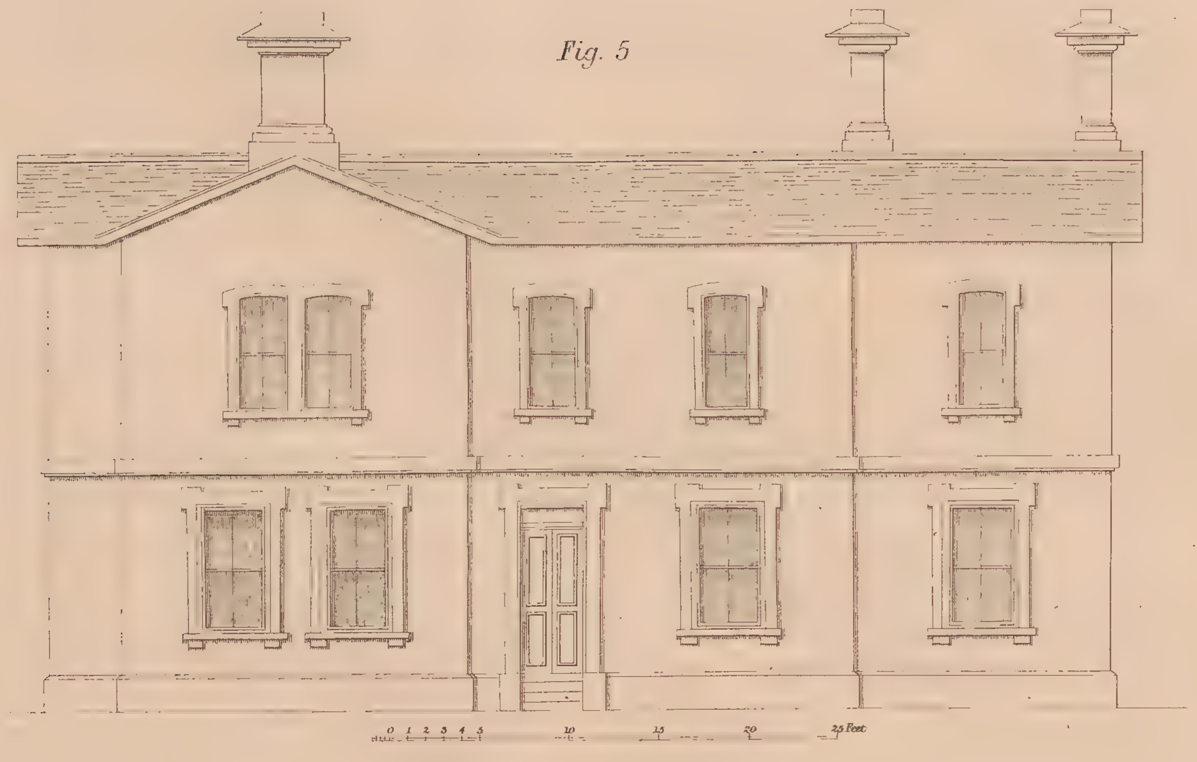
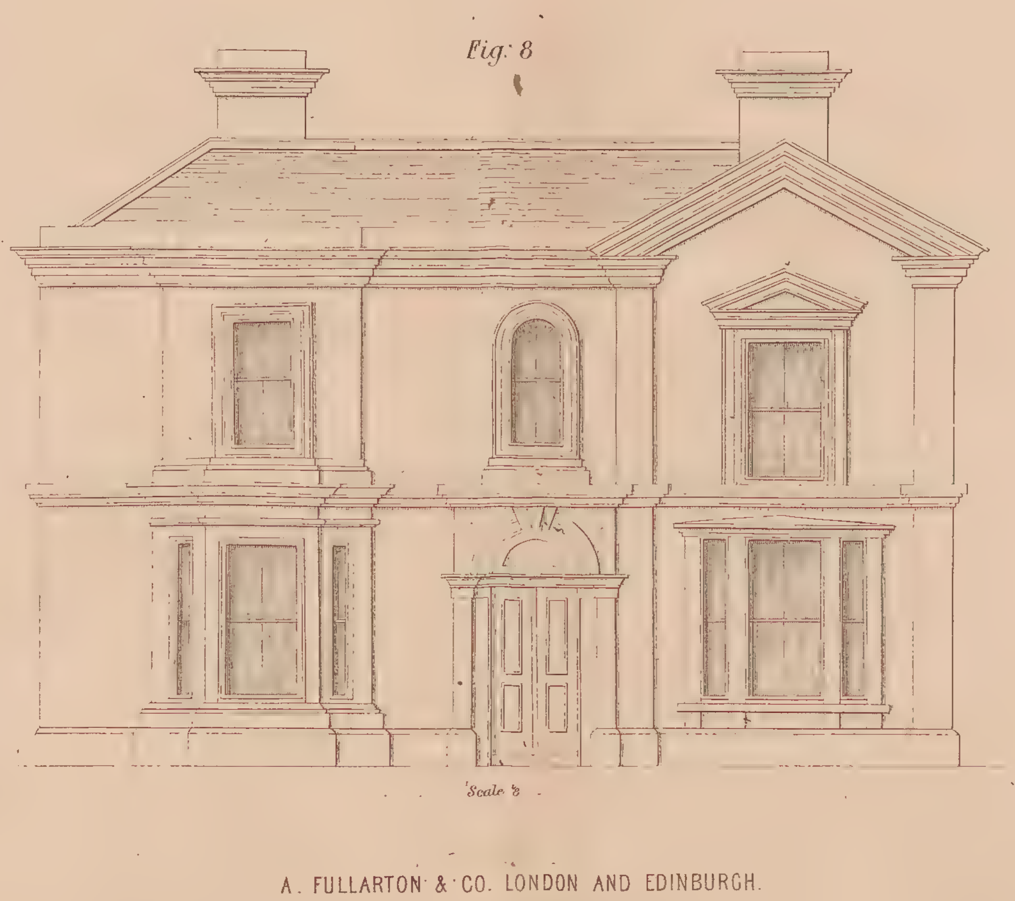
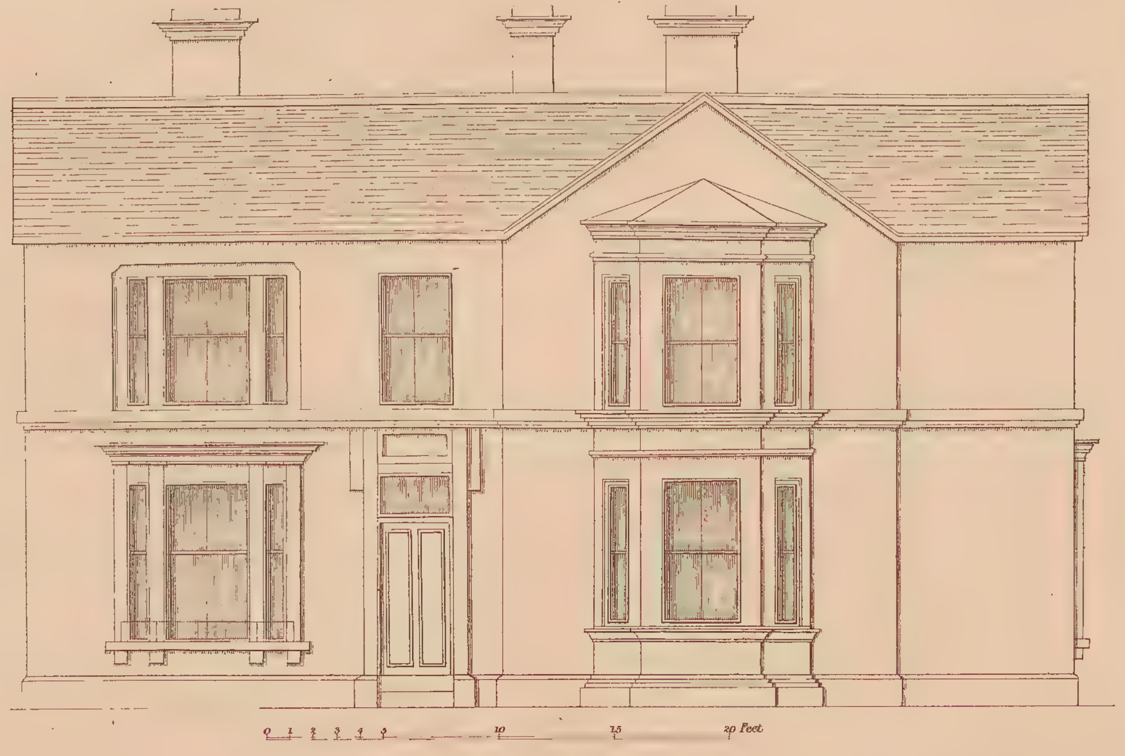

0 1 2 3 4 5 10 15 20 25 Feet

Fig. 8



Scale ⅛

Fig. 7


0 1 2 3 4 5 10 15 20 Feet

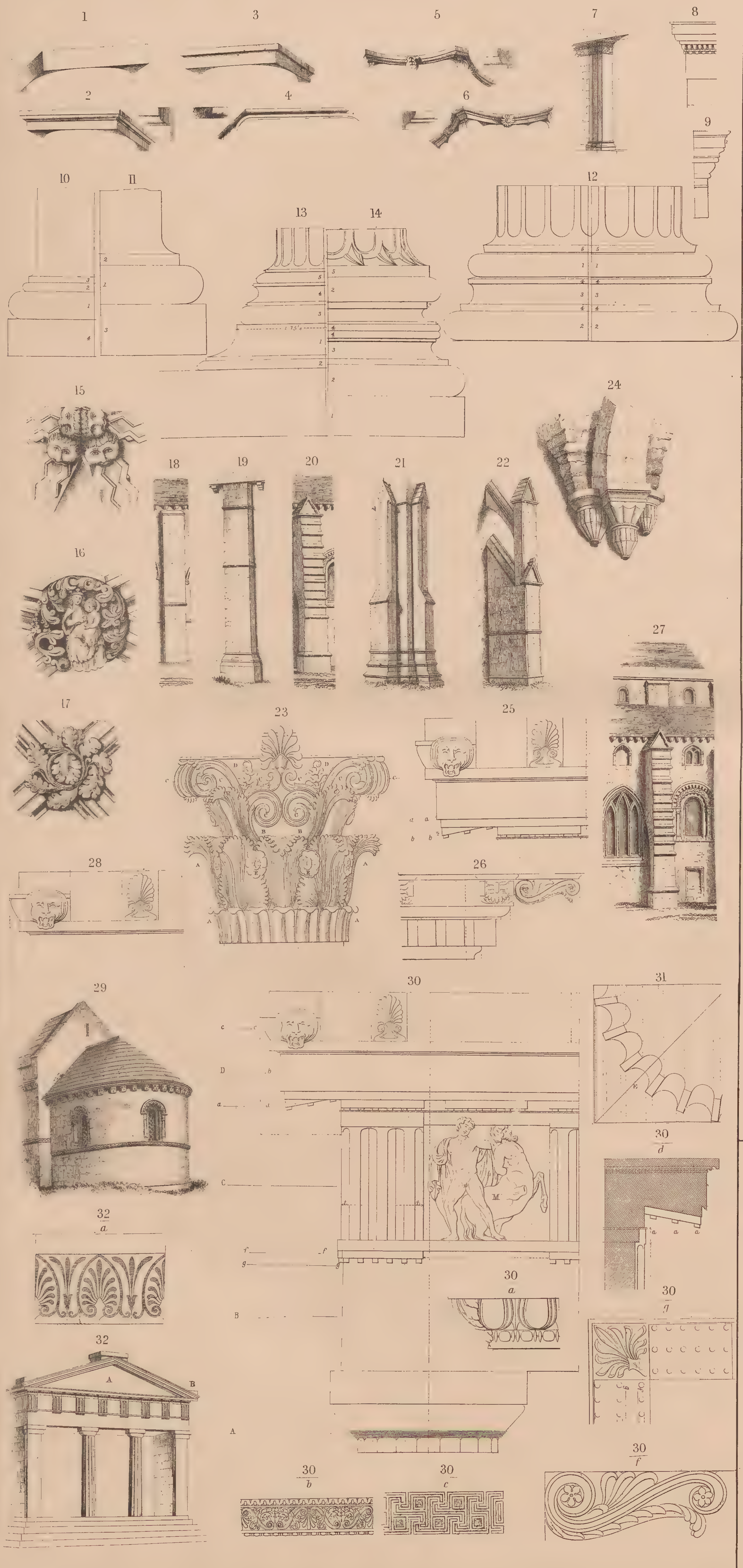
A. FULLARTON & CO. LONDON AND EDINBURGH.

Engraved by J Bartholomew, Edinburgh

ILLUSTRATION OF THE PRINCIPAL TERMS USED IN ARCHITECTURAL DESIGN AND BUILDING CONSTRUCTION.

PLATE D.

SECTION FIRST,—TERMS USED IN ARCHITECTURAL DESIGN, CLASSICAL AND GOTHIC, FIGS. 1 TO 36.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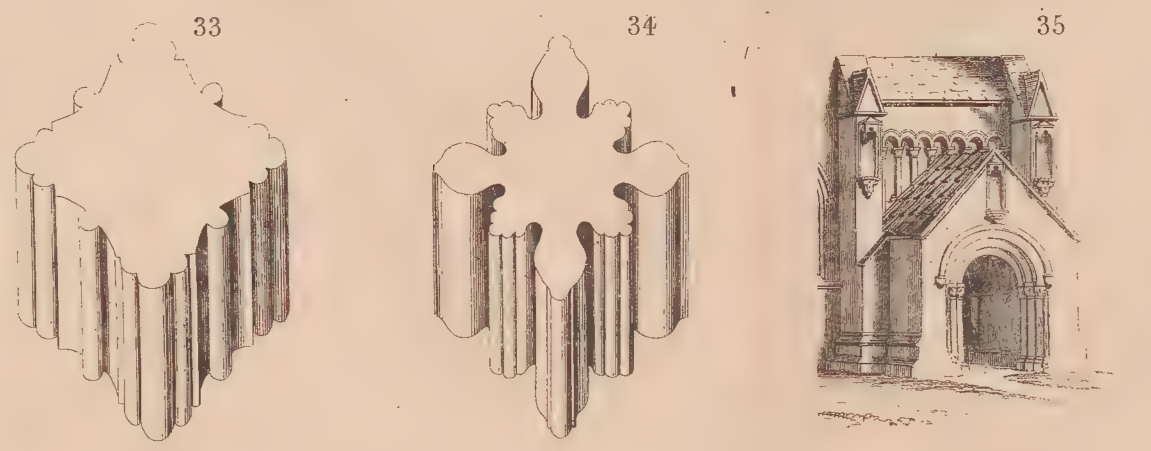
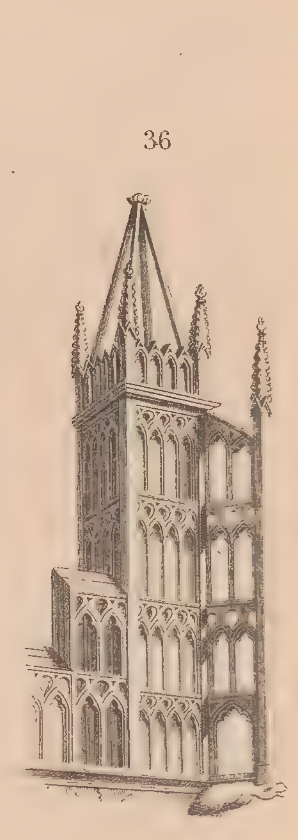
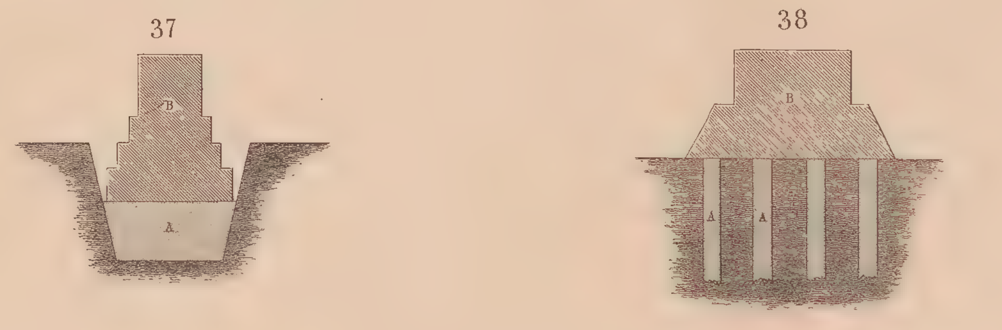
30 a
30 b
30 c
30 d
30 f
30 g
31
32
32 a

SECTION FIRST CONTINUED.

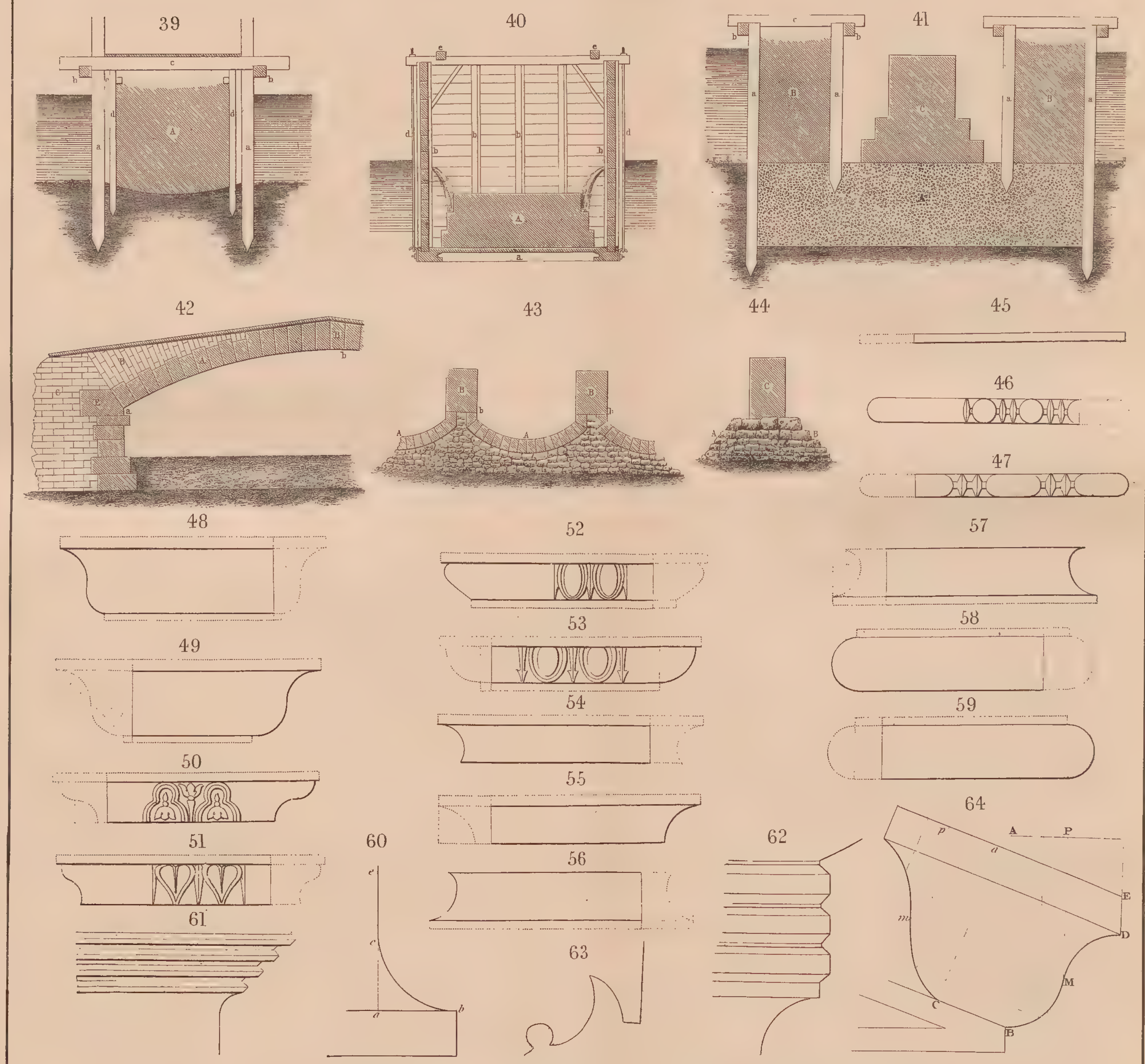




SECTION SECOND,—TERMS USED IN EXCAVATING WORK, FIGS. 37 & 38.



SECTION THIRD,—TERMS USED IN BRICKLAYING AND MASONRY, FIGS. 39 TO 64.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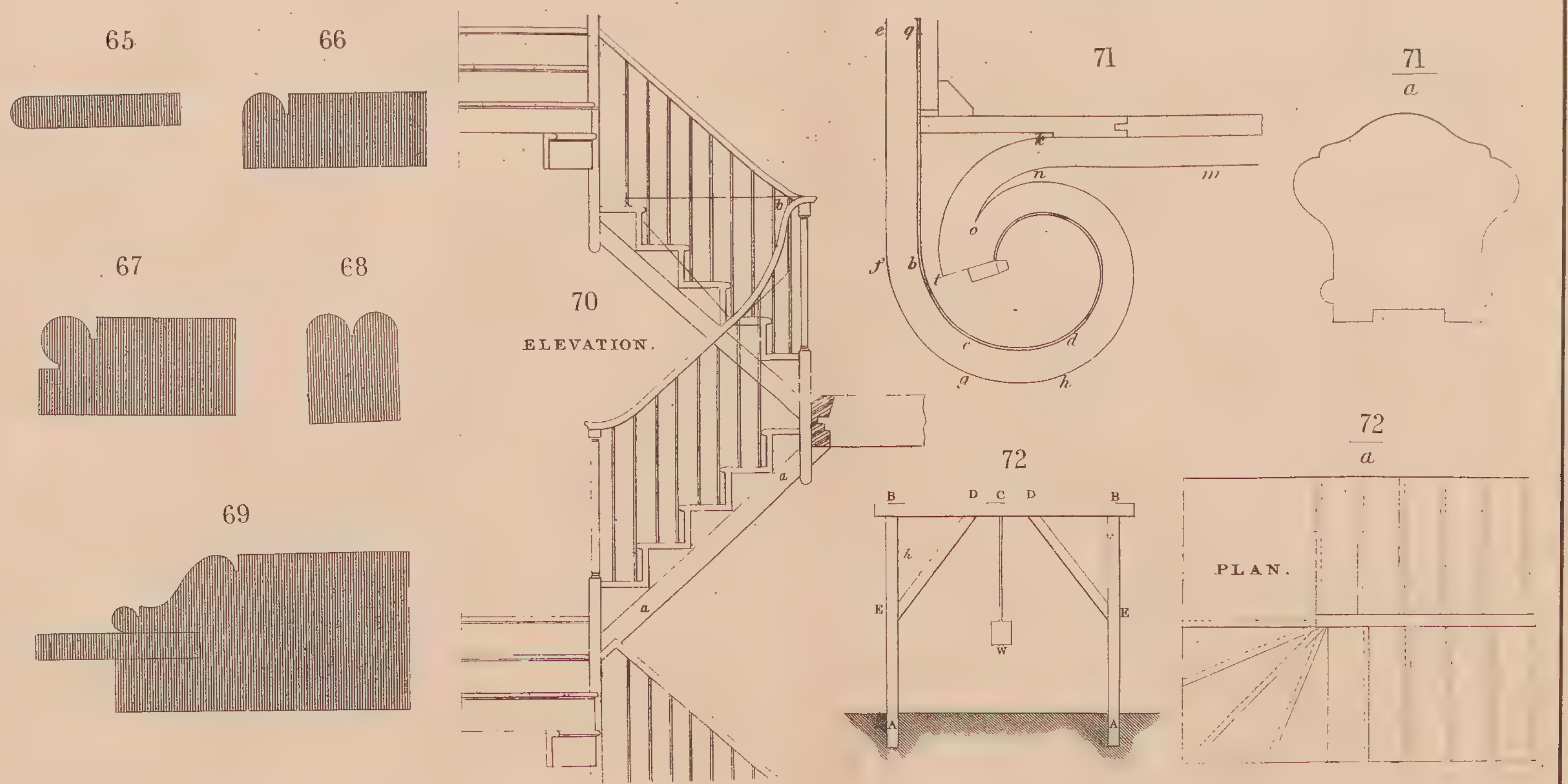
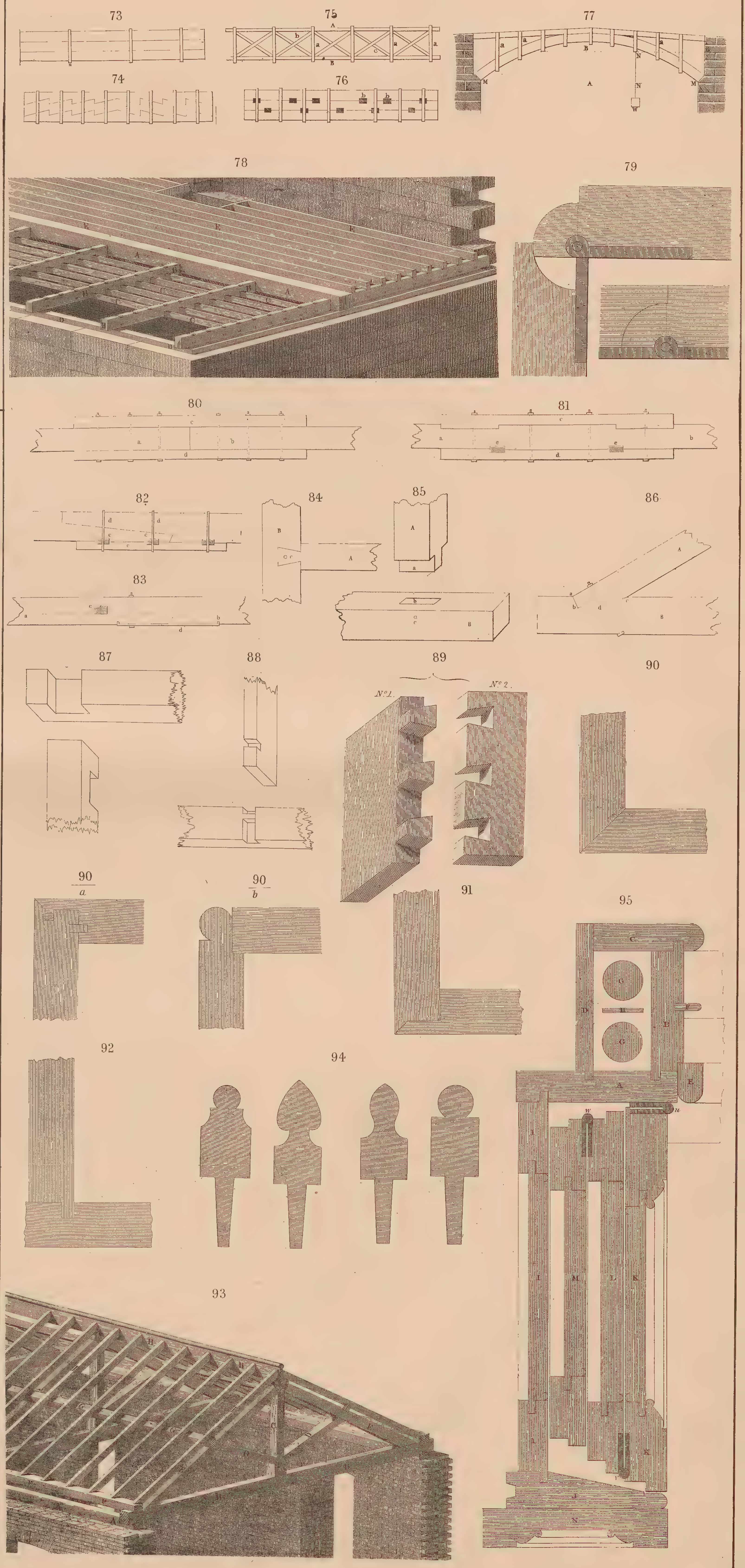
SECTION FOURTH,—TERMS USED IN CARPENTRY AND JOINERY, FIGS. 65 TO 95.


65
66
67
68
69
70
ELEVATION.
71
71 a
72
72 a
PLAN.

SECTION FOURTH CONTINUED.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N° 1.
N° 2.
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90 a
90 b
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SHEET E

EXAMPLES OF

CONTINENTAL DOMESTIC ARCHITECTURE.

Fig. 1.

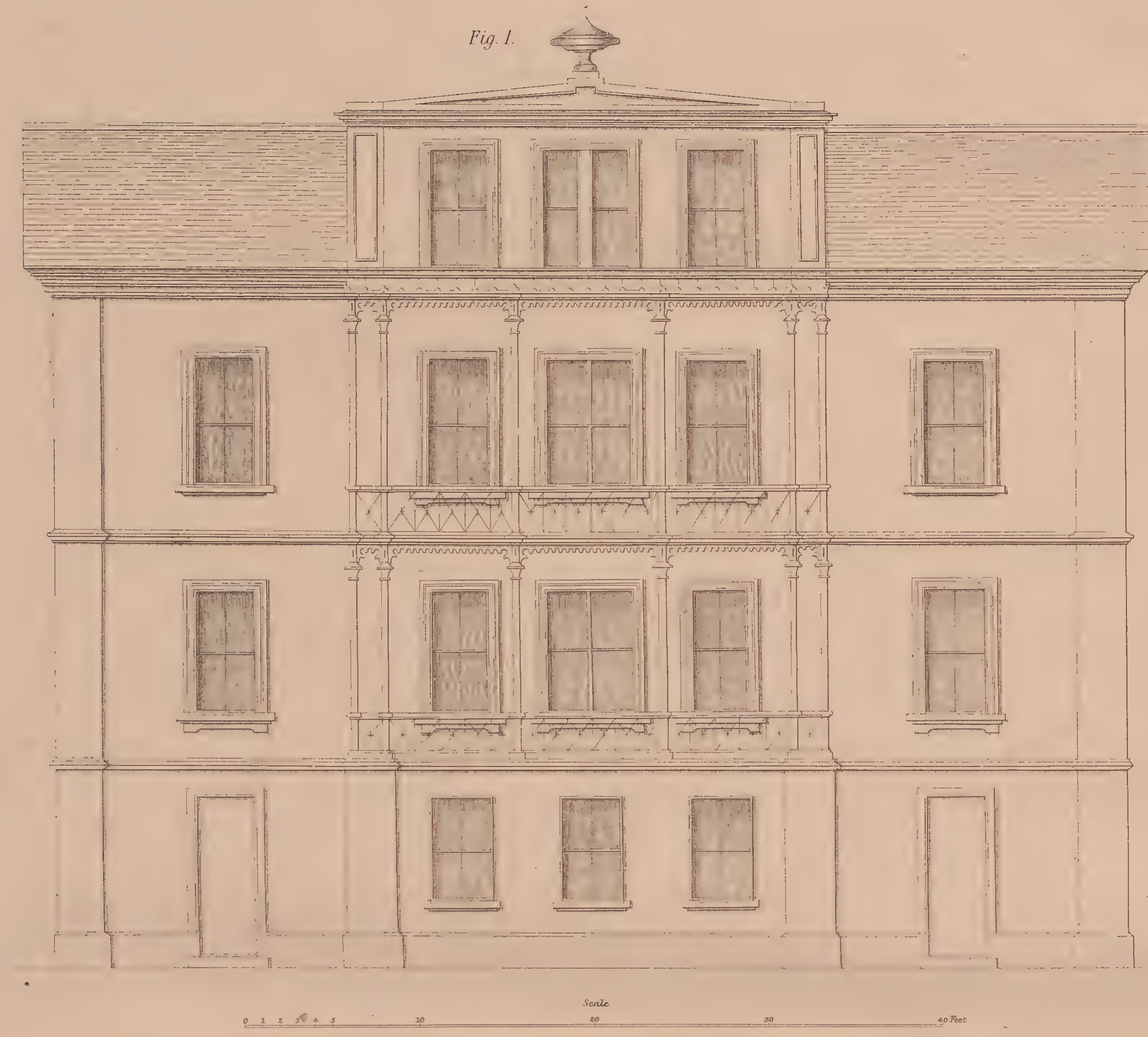

Scale
0 1 2 3 4 5 10 20 30 40 Feet

Fig. 2.

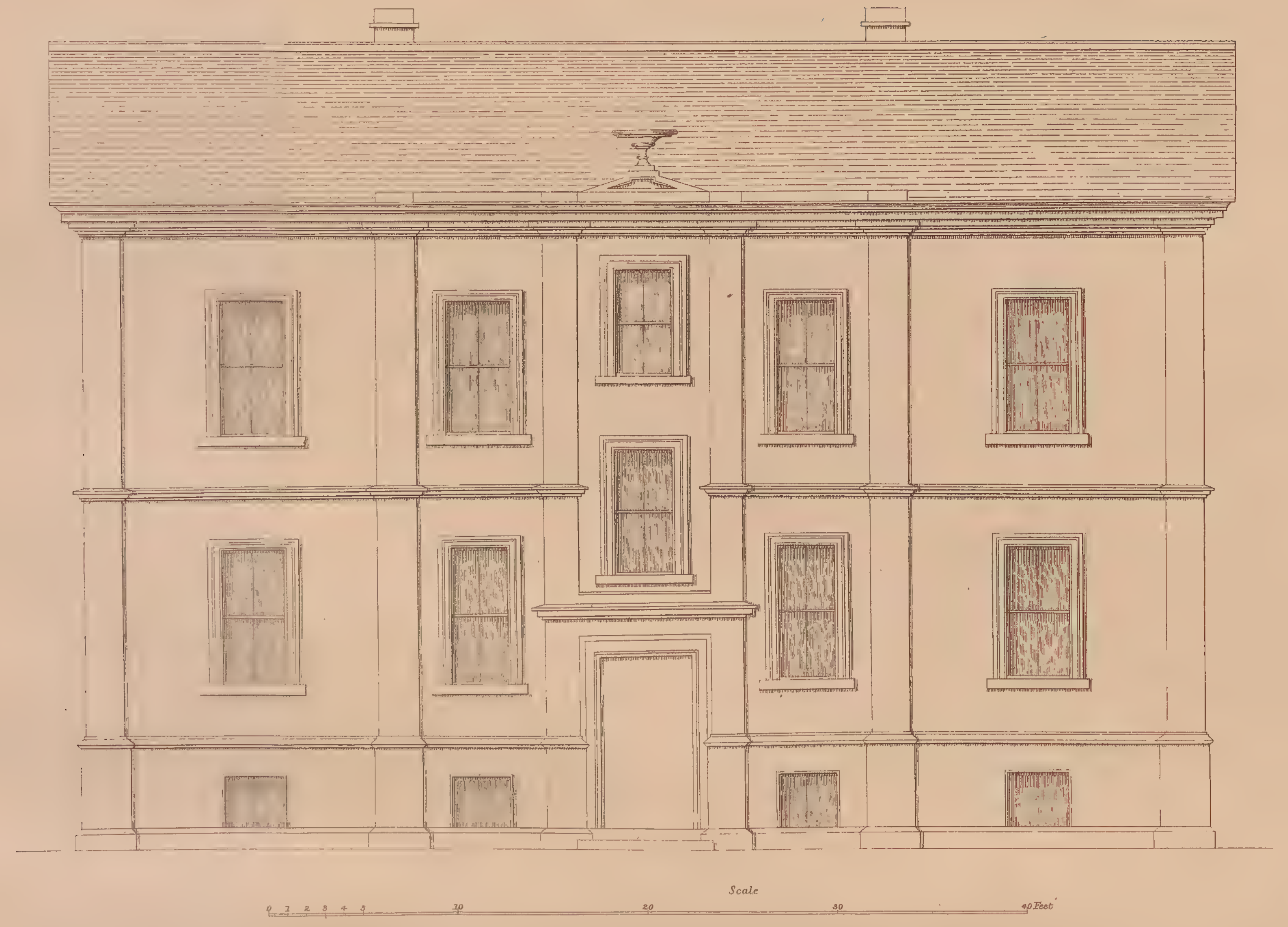

Scale
0 1 2 3 4 5 10 20 30 40 Feet

Fig. 4.

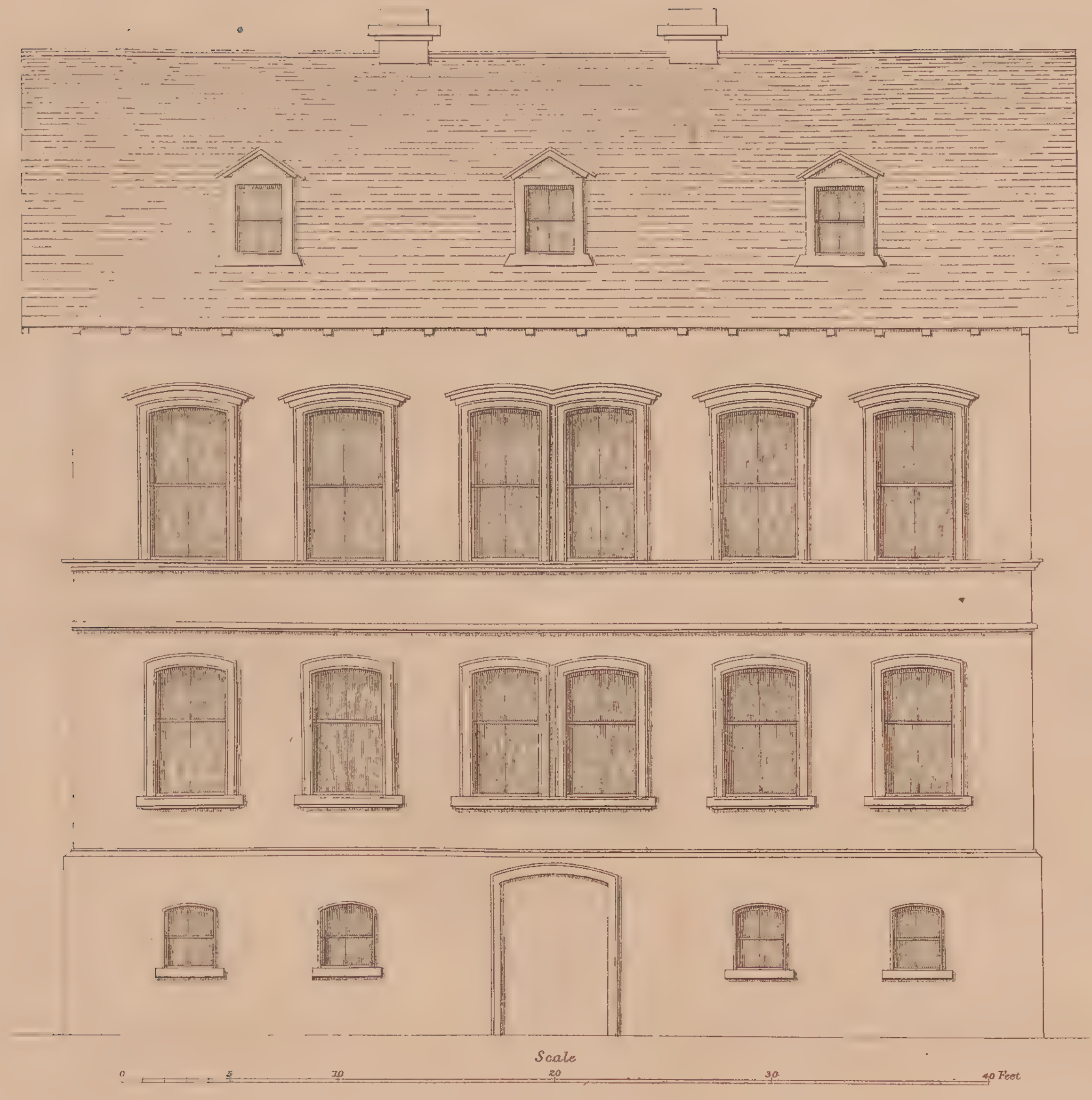

Scale
0 5 10 20 30 40 Feet

Fig. 3.

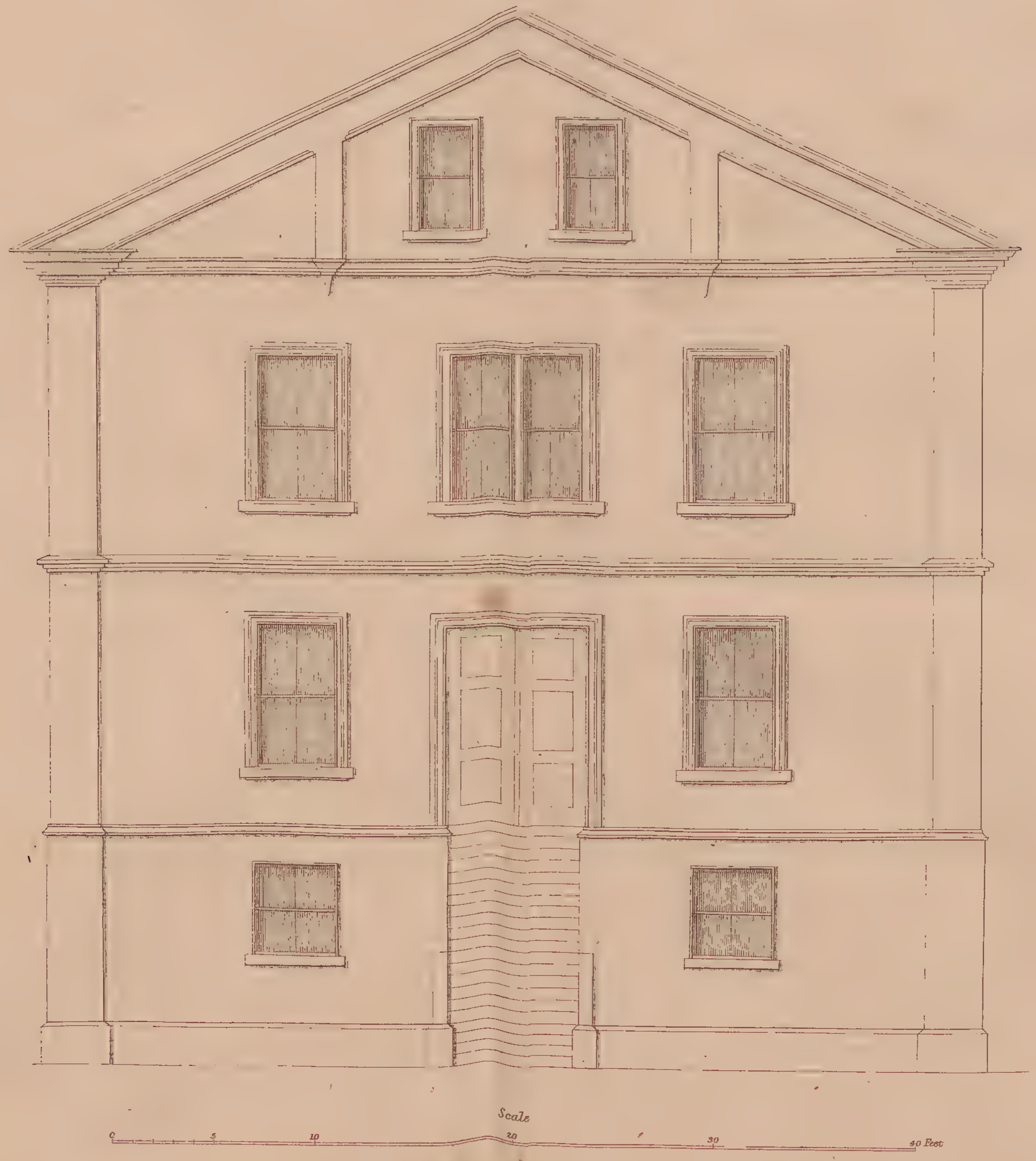
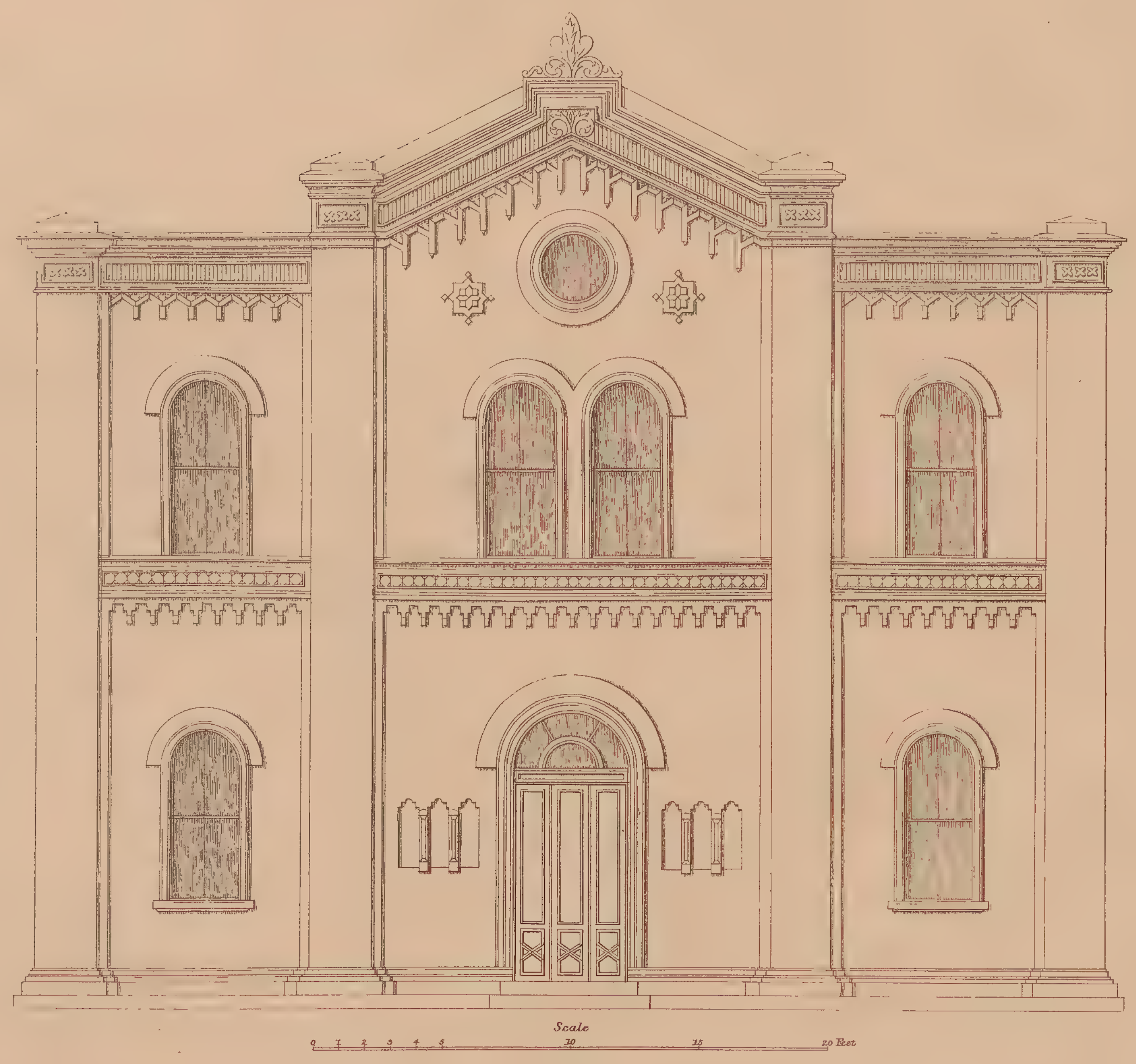

Scale
0 5 10 20 30 40 Feet

Fig. 5.


Scale
0 1 2 3 4 5 10 15 20 Feet

SHEET F.

EXAMPLES OF
DOMESTIC CONTINENTAL ARCHITECTURE.

Fig. 3.

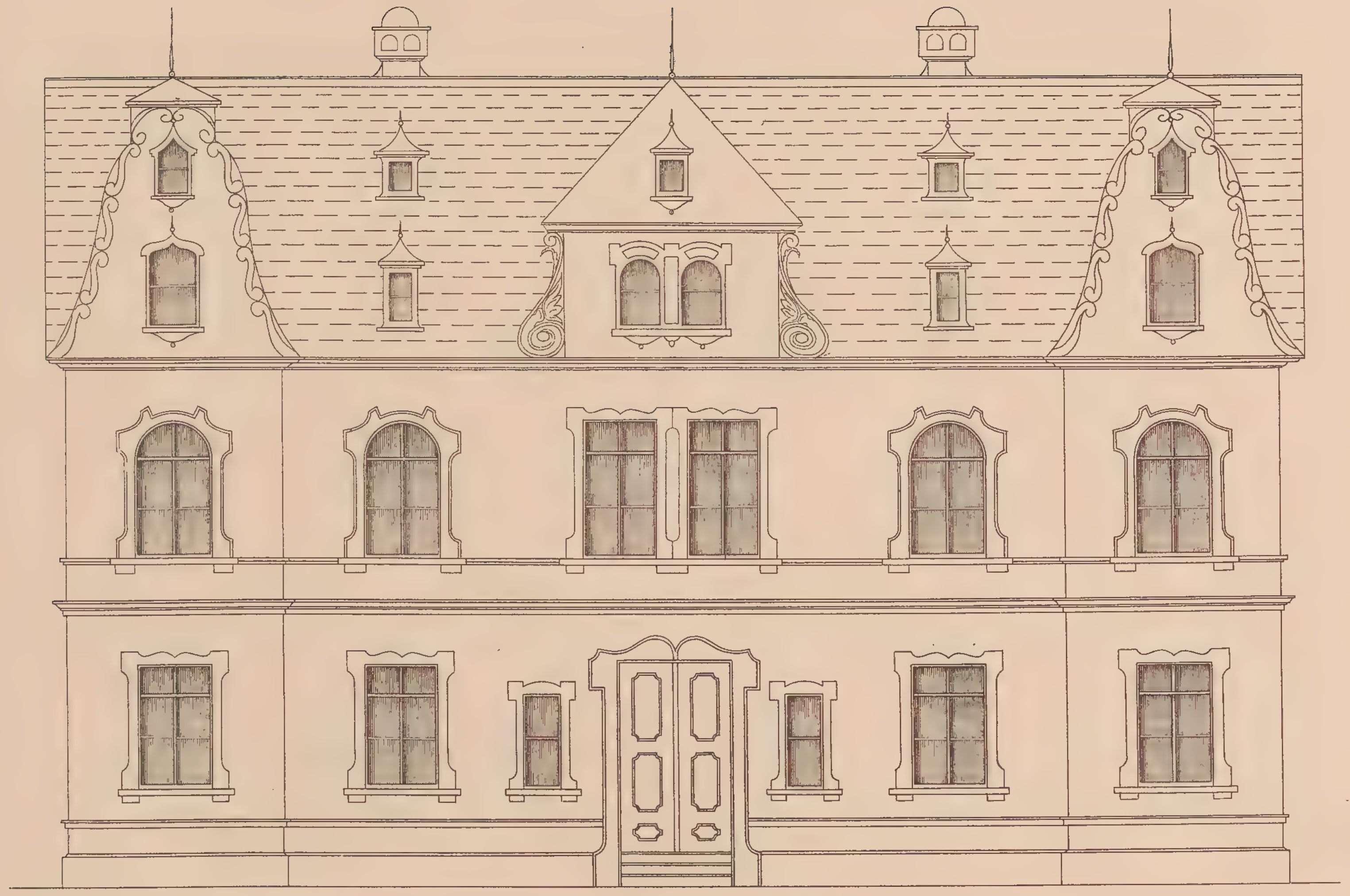


Fig. 2.

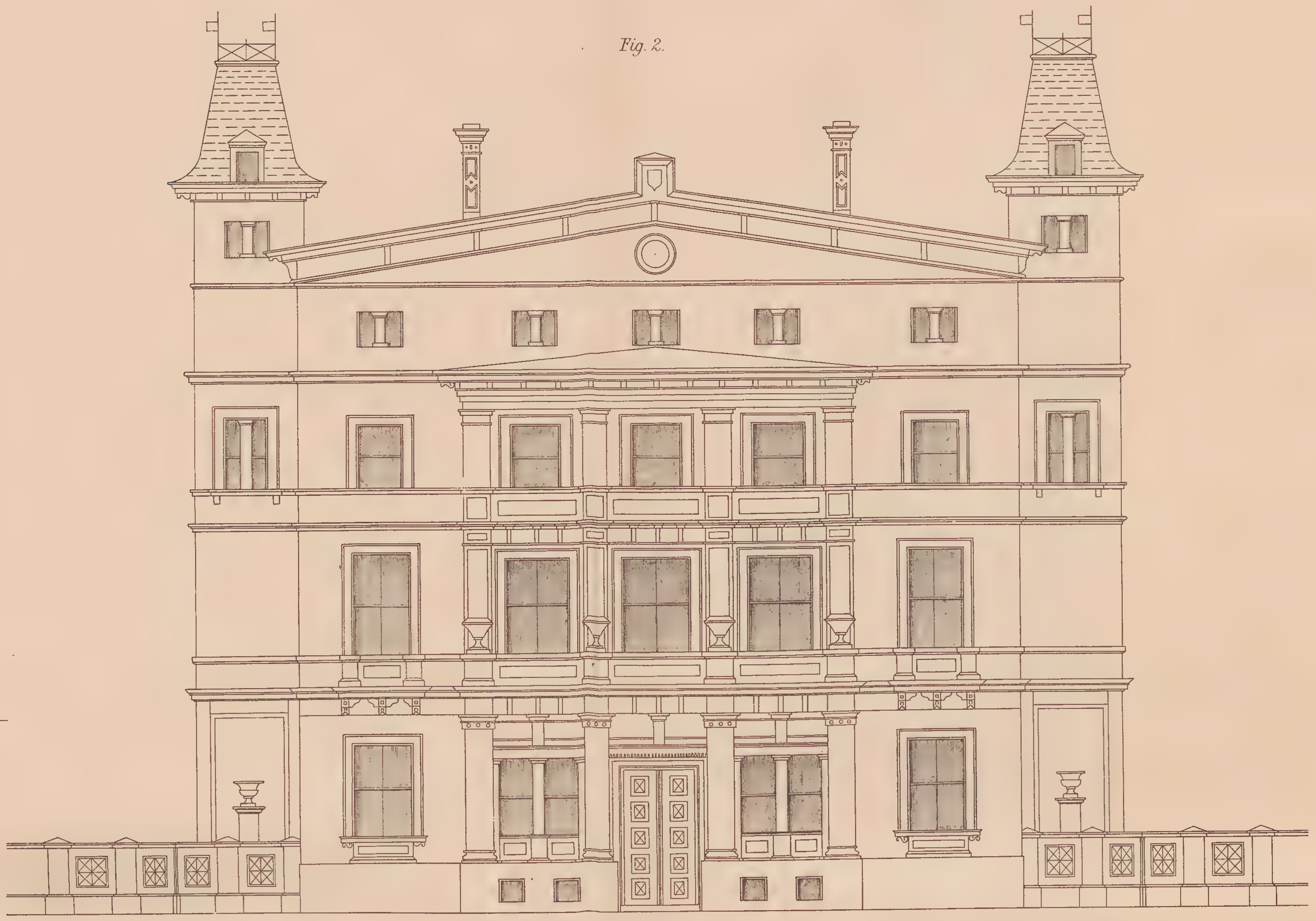


Fig. 4.

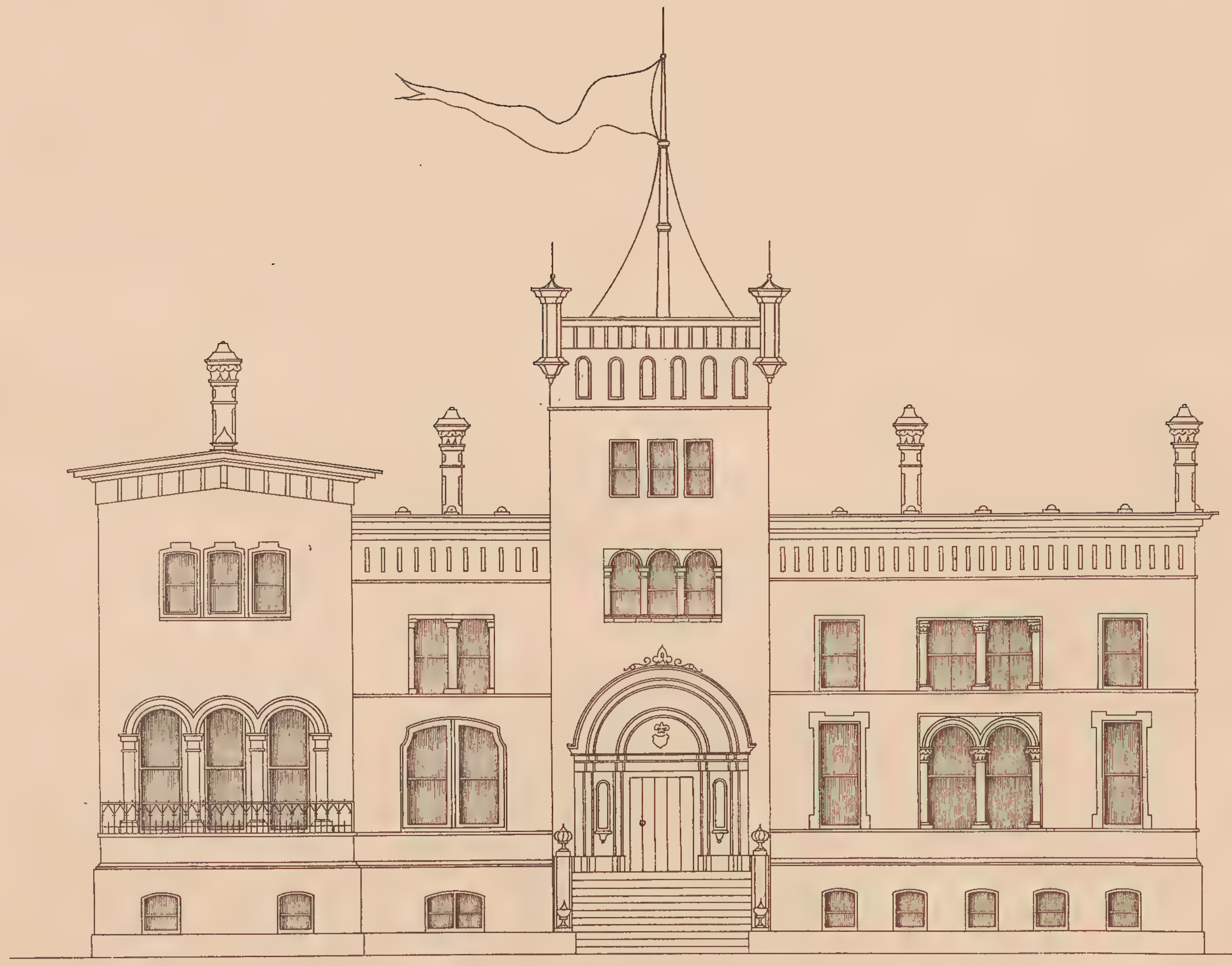


Fig. 1.

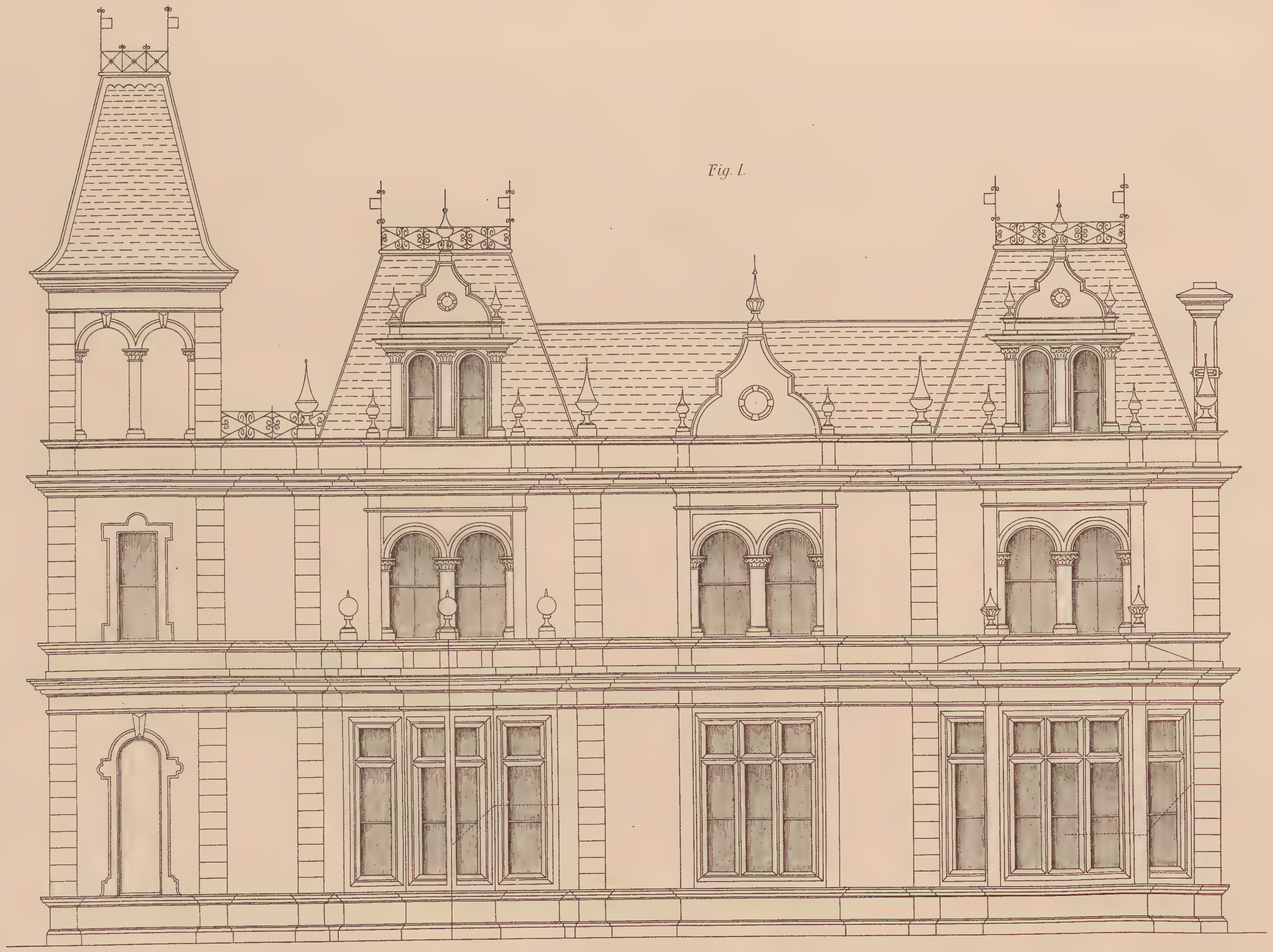
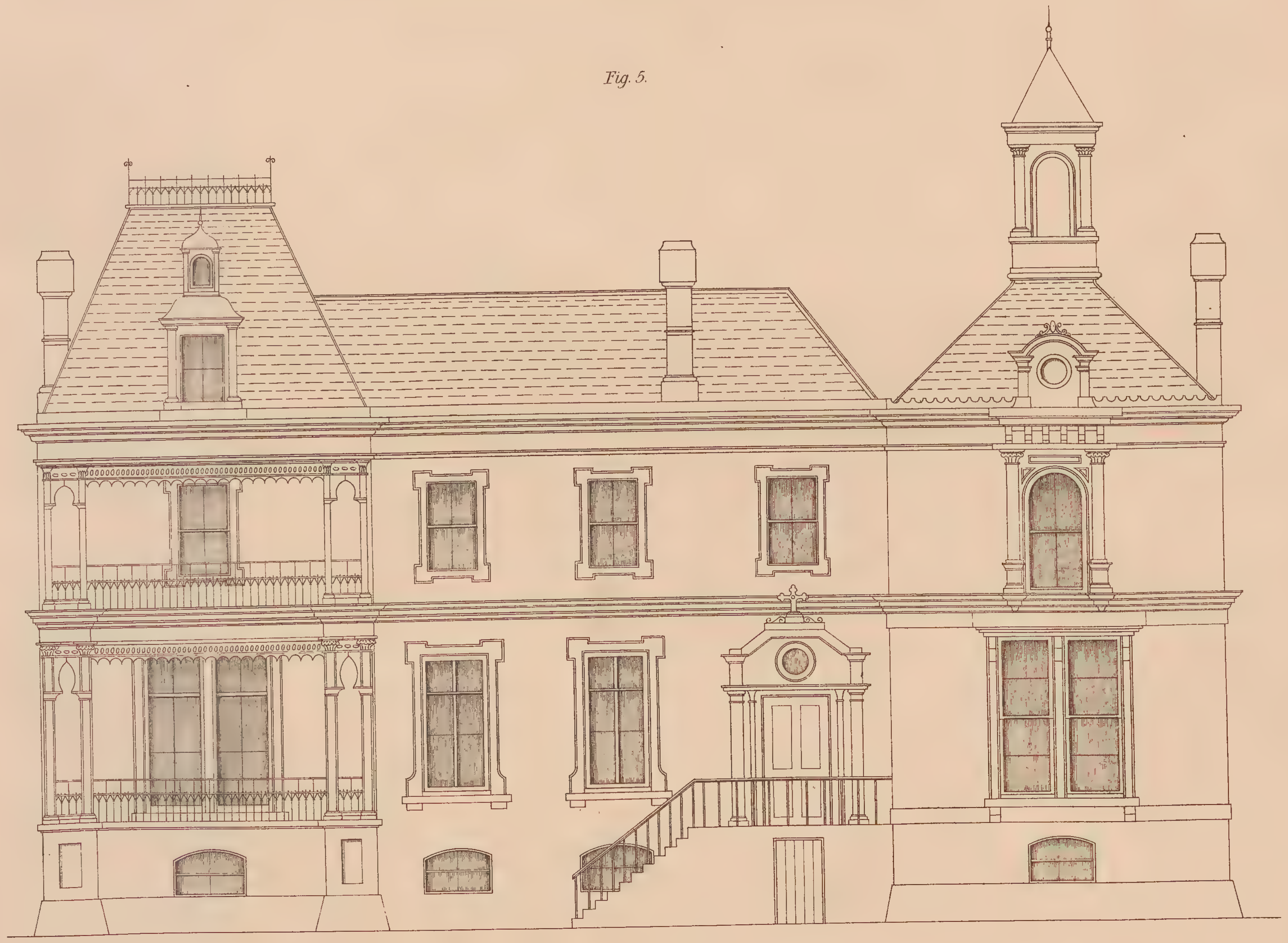


Fig. 5.

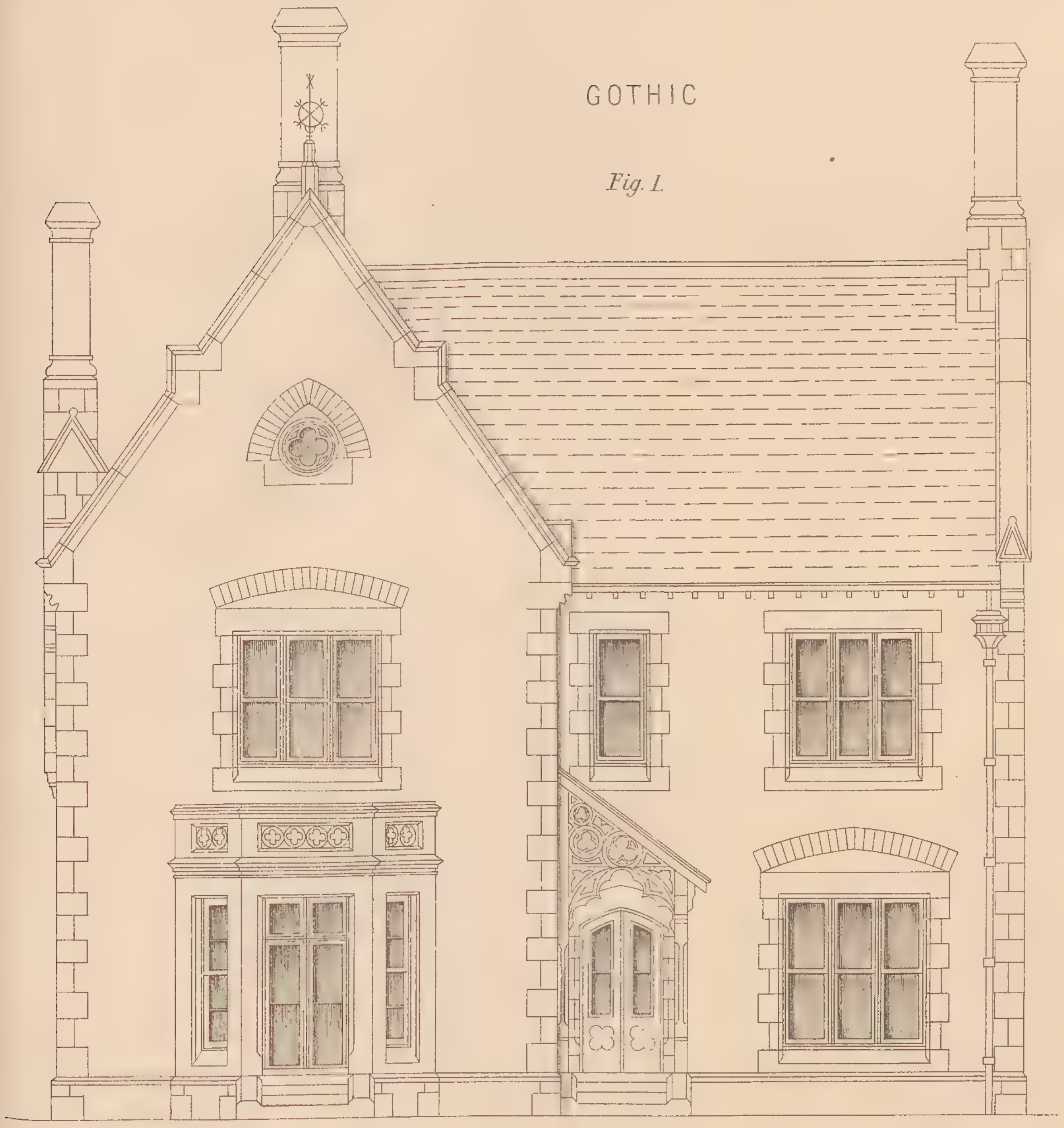


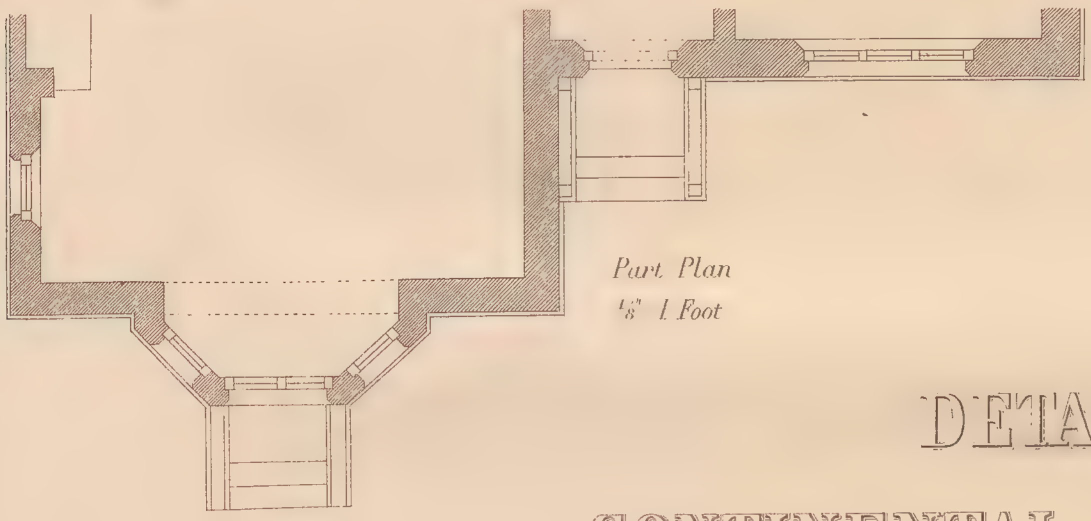
A. FULLARTON & CO. LONDON AND EDINBURGH.

EXAMPLES OF DOMESTIC ARCHITECTURE.

GOTHIC

Fig. 1.

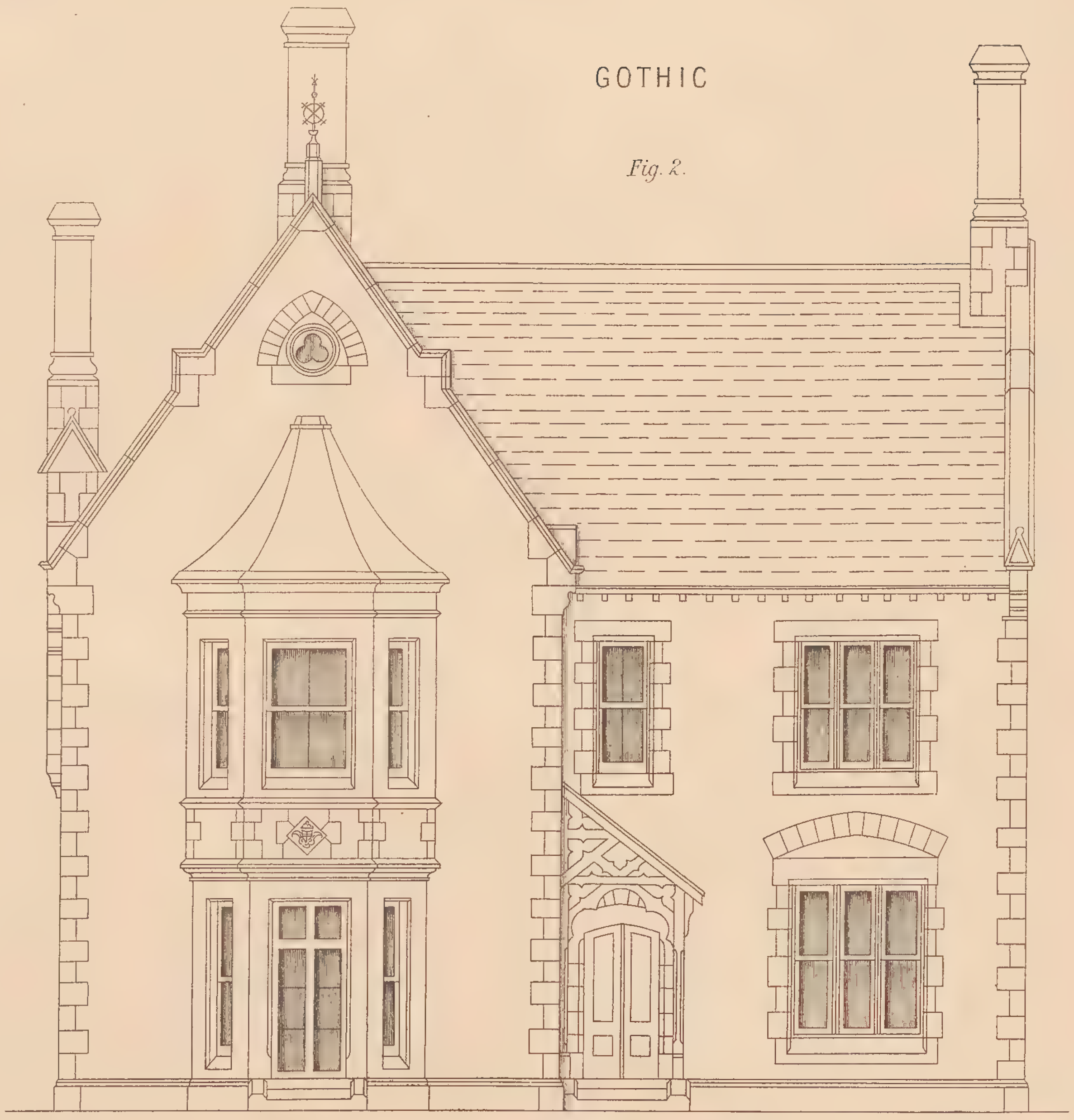


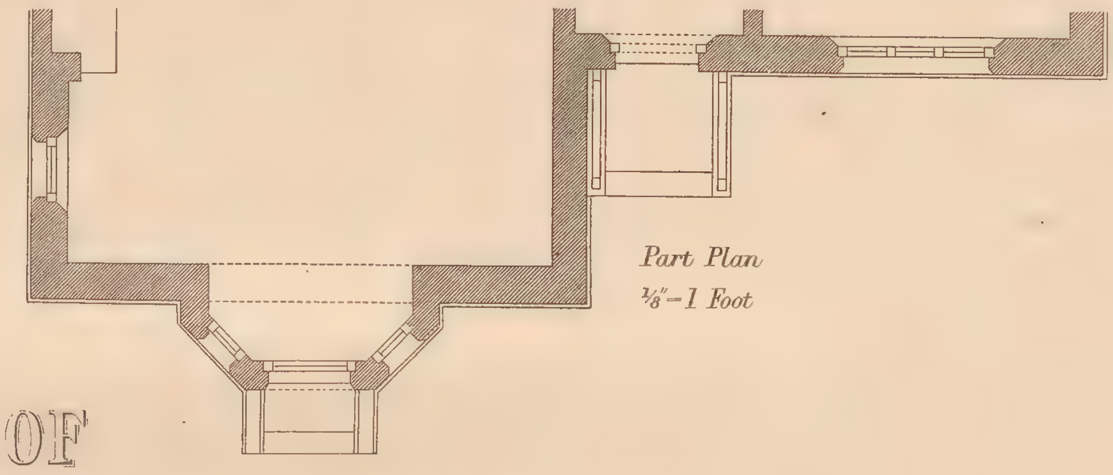


Part Plan
1/8" 1 Foot

GOTHIC

Fig. 2.





Part Plan
1/8"=1 Foot

DETAILS OF CONTINENTAL ARCHITECTURE.

Fig. 3.

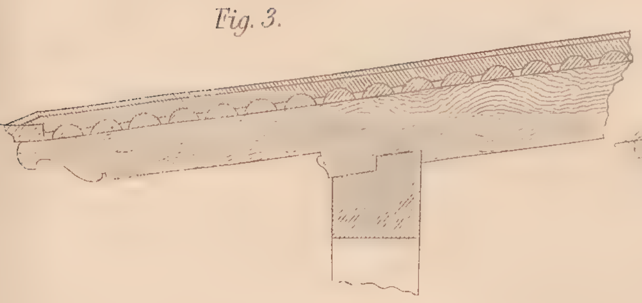


Fig. 4.

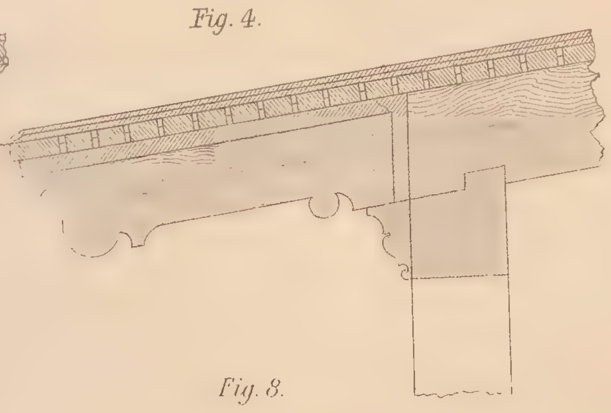


Fig. 5.

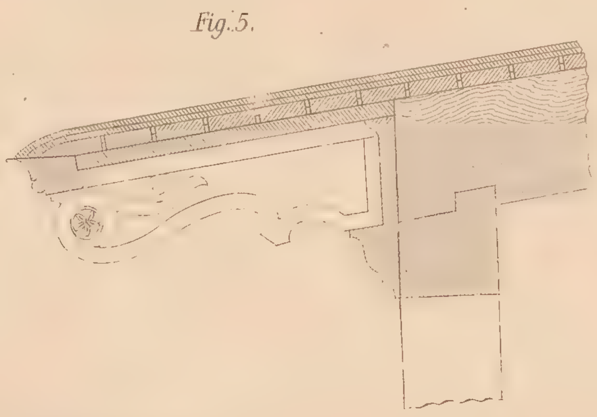


Fig. 6.

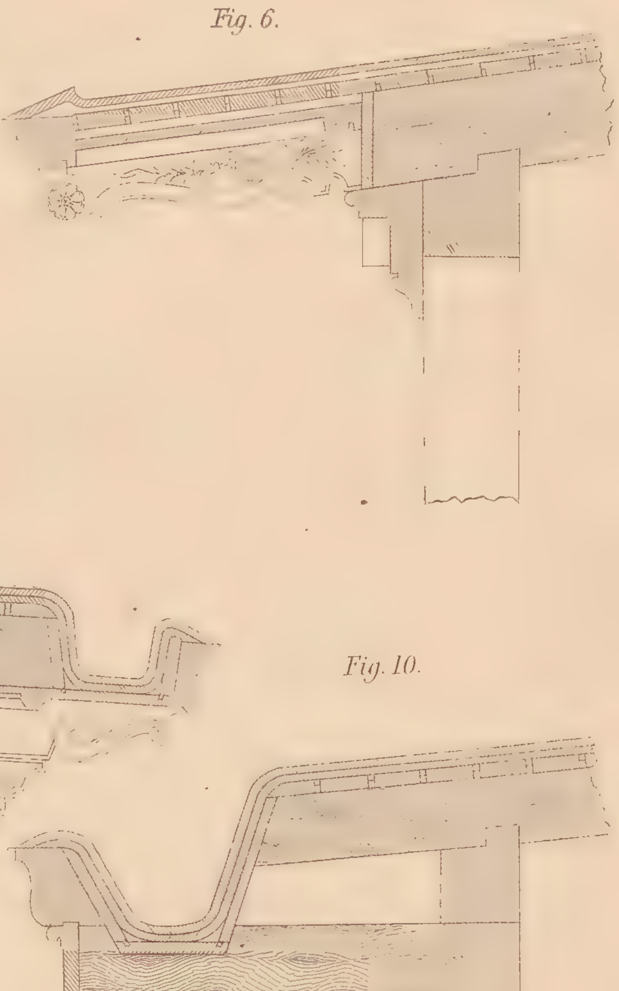


Fig. 7.

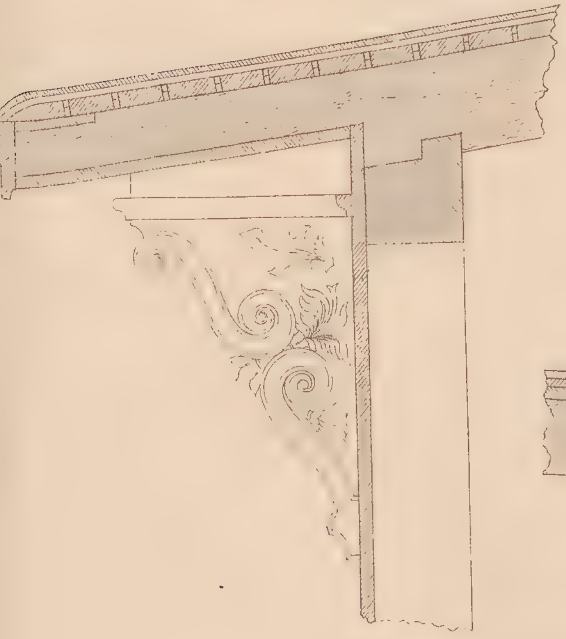


Fig. 8.

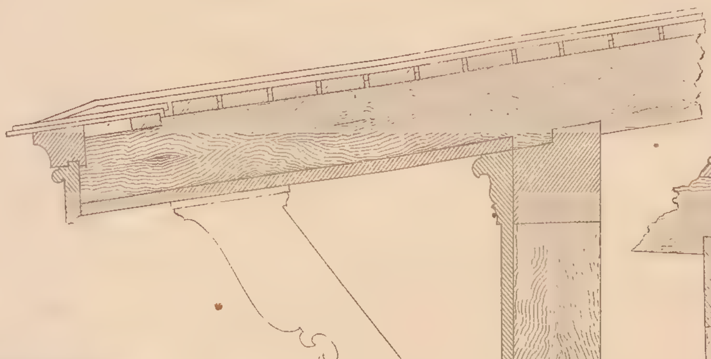


Fig. 13.

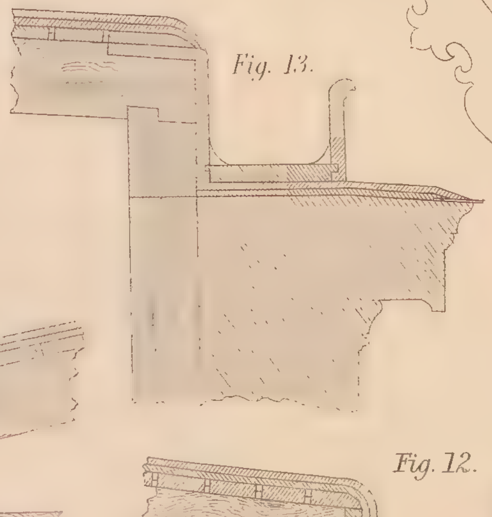


Fig. 9.

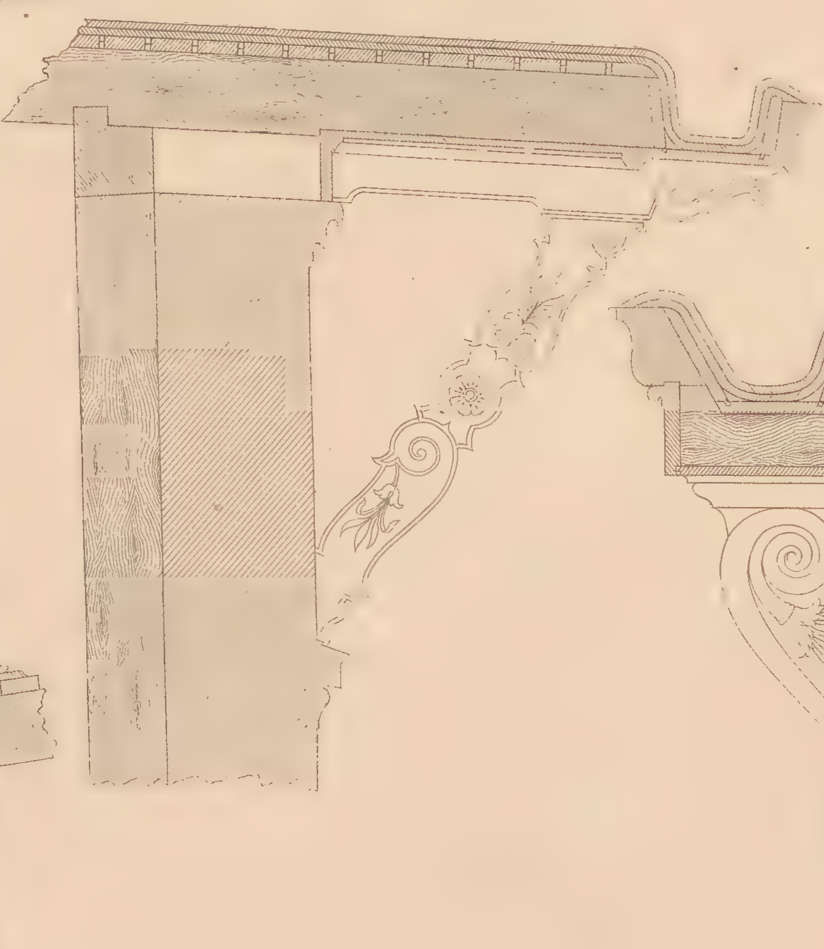


Fig. 10.

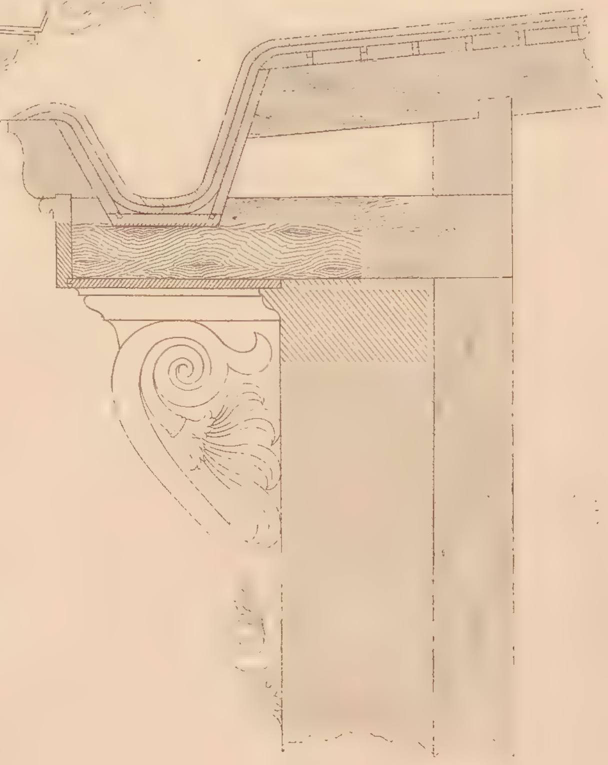


Fig. 11.

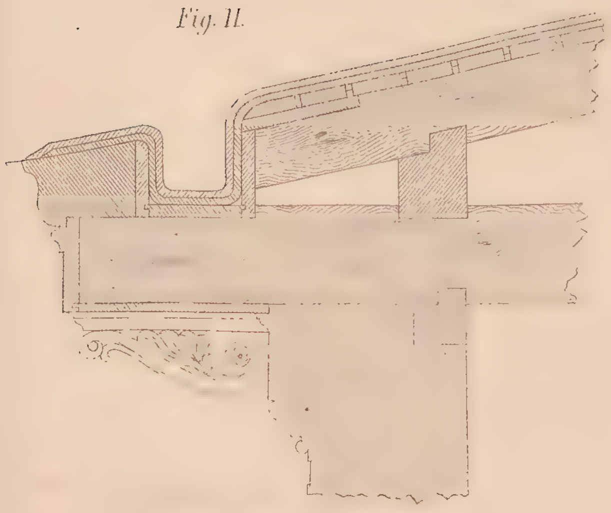
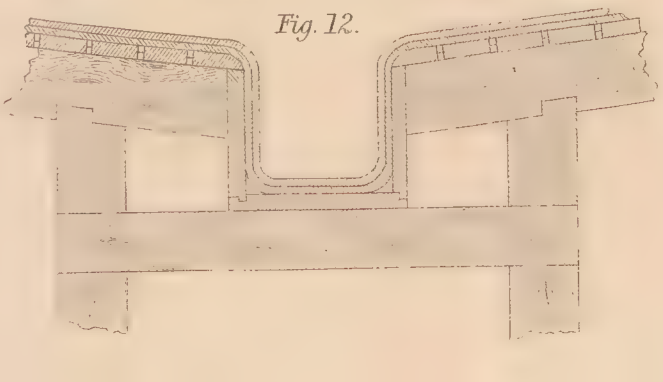
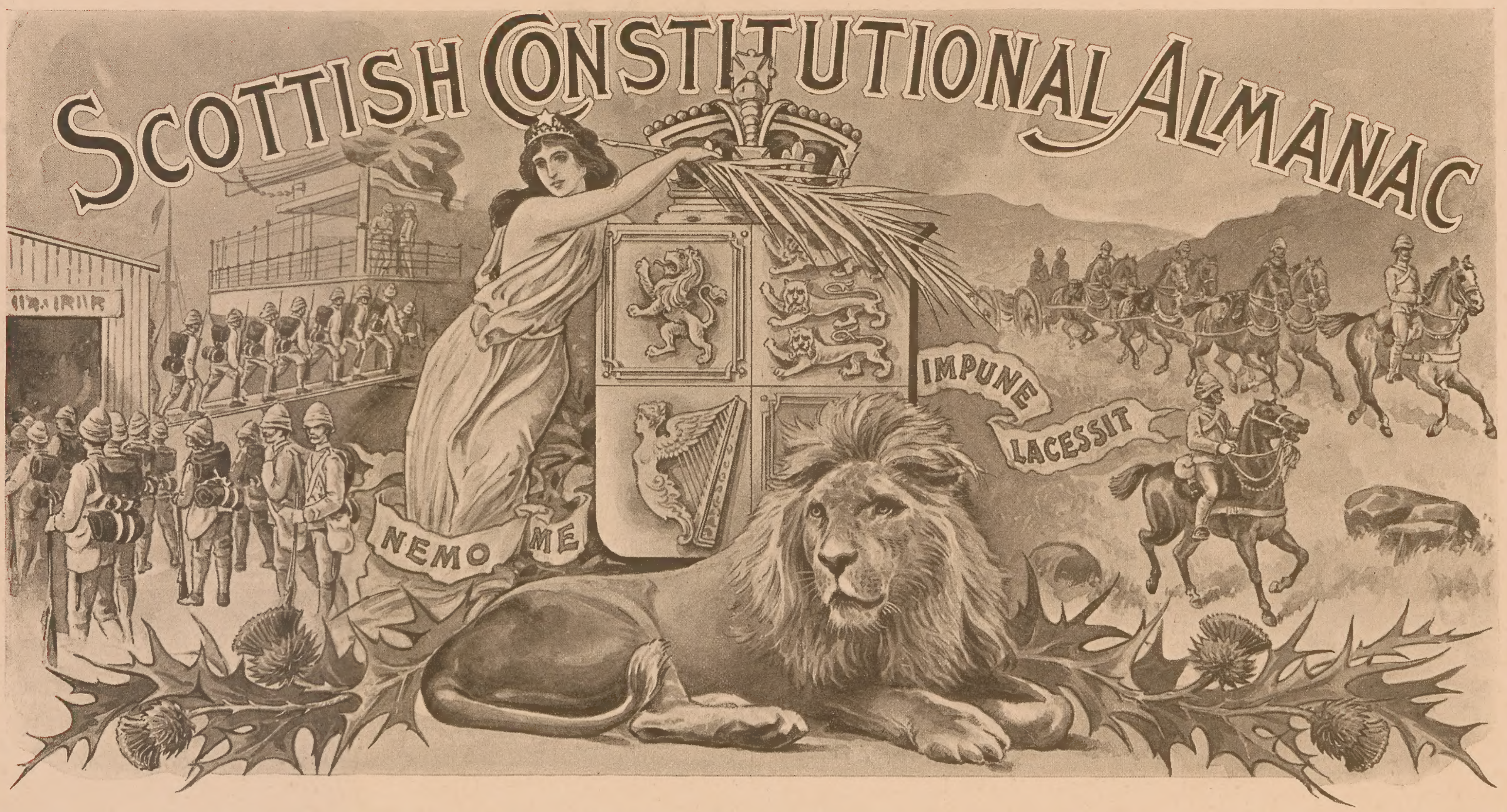


Fig. 12.



SCOTTISH CONSTITUTIONAL ALMANAC



POSTAL INFORMATION

LETTER POST

Inland

Not exceed. 4 oz.	.	1d
,, 6 oz.	.	1½d
,, 8 oz.	.	2d
,, 10 oz.	.	2½d
,, 12 oz.	.	3d

And so on, ½d. for every *additional* 2 oz. or fraction thereof.

POSTAL ORDERS

For 1/ and 1/6	Com. ½d
,, 2/, 2/6, 3/, 3/6, 4/, 4/6, 5/, 7/6, 10/, 10/6	,, 1d
,, 15/ and 20/	,, 1½d

POST CARDS

Thin (1 shape)	10 for 5½d
Thick (2 shapes)	10 for 6d

BOOK POST

Inland

Not exceed. 2 oz. . ½d

Above 2 oz. comes under Letter Post Rates.

NEWSPAPERS

For each registered copy ½d., but not more than on a Book Packet.

CALENDAR 1900

BANK HOLIDAYS

Scotland		England	
New Year's Day .	Jan. 1	Good Friday .	April 13
Good Friday .	April 13	Easter Monday	April 16
Monday . .	May 7	Whit Monday .	June 4
Monday . .	Aug. 6	Monday . .	Aug. 6
Christmas Day .	Dec. 25	Christmas Day .	Dec. 25
		Boxing Day .	Dec. 26

And any day appointed by Royal Proclamation.

TERMS

Scotland		England	
Candlemas .	Feb. 2	Lady Day .	Mar. 25
Whitsunday .	May 15	Midsummer .	June 24
Lammas . .	Aug. 1	Michaelmas .	Sept. 29
Martinmas . .	Nov. 11	Christmas .	Dec. 25

Scotch Terms falling on Sunday held the following day.
Removal Terms in Scotland—28th May and 28th November.

TRUTH ABOUT THE TRANSVAAL

⁂

1833. Slavery abolished in Cape Colony.

1835. Boers quitted Cape Colony in disgust.

1877. Transvaal State being bankrupt, and threatened with invasion by hostile natives on all sides, the British Government took possession without opposition, defeated the Zulus, and restored the finances.

1881. Boers rebelled. Mr Gladstone declared the Queen's Authority must be vindicated. Boers defeated British at Majuba. Mr Gladstone agreed to grant them independence, subject to certain conditions.

1884. Kruger came to England and got a new Convention with still more favourable conditions from Mr Gladstone's Government.

1885. The Boers broke the Convention and invaded Bechuanaland. Necessary to send Sir Charles Warren with an expedition to restore order, at a cost of a million pounds.

1885-99. Boers refused all political rights to English settlers, prevented the education of their children in the English language, and subjected them to innumerable petty tyrannies, whilst making them pay practically all the taxes. At the same time, they continued their oppressive treatment of the natives.

1895. The Uitlanders were taking steps to enforce redress of their grievances when the unfortunate Jameson raid checked the movement.

1895-9. The Boers armed themselves to the teeth for war with Britain.

1899. The Uitlanders petitioned the Queen to use the influence of this country on their behalf. Mr Chamberlain made moderate proposals, which the Boers rejected. The Boers declared war against Britain, invaded her territory, and declared large provinces of it to be annexed to their own Republic.

JANUARY						
S	..	–	7	14	21	28
M	..	1	8	15	22	29
Tu	..	2	9	16	23	30
W	..	3	10	17	24	31
Th	..	4	11	18	25	...
F	..	5	12	19	26	...
Sa	..	6	13	20	27	...

FEBRUARY						
S	..	–	4	11	18	25
M	..	–	5	12	19	26
Tu	..	–	6	13	20	27
W	..	–	7	14	21	28
Th	..	1	8	15	22	...
F	..	2	9	16	23	...
Sa	..	3	10	17	24	...

MARCH						
S	..	–	4	11	18	25
M	..	–	5	12	19	26
Tu	..	–	6	13	20	27
W	..	–	7	14	21	28
Th	..	1	8	15	22	29
F	..	2	9	16	23	30
Sa	..	3	10	17	24	31

APRIL						
S	..	1	8	15	22	29
M	..	2	9	16	23	30
Tu	..	3	10	17	24	...
W	..	4	11	18	25	...
Th	..	5	12	19	26	...
F	..	6	13	20	27	...
Sa	..	7	14	21	28	...

MAY						
S	..	–	6	13	20	27
M	..	–	7	14	21	28
Tu	..	1	8	15	22	29
W	..	2	9	16	23	30
Th	..	3	10	17	24	31
F	..	4	11	18	25	...
Sa	..	5	12	19	26	...

JUNE						
S	..	–	3	10	17	24
M	..	–	4	11	18	25
Tu	..	–	5	12	19	26
W	..	–	6	13	20	27
Th	..	–	7	14	21	28
F	..	1	8	15	22	29
Sa	..	2	9	16	23	30

JULY						
S	..	1	8	15	22	29
M	..	2	9	16	23	30
Tu	..	3	10	17	24	31
W	..	4	11	18	25	...
Th	..	5	12	19	26	...
F	..	6	13	20	27	...
Sa	..	7	14	21	28	...

AUGUST						
S	..	–	5	12	19	26
M	..	–	6	13	20	27
Tu	..	–	7	14	21	28
W	..	1	8	15	22	29
Th	..	2	9	16	23	30
F	..	3	10	17	24	31
Sa	..	4	11	18	25	...

SEPTEMBER						
S	–	2	9	16	23	30
M	–	3	10	17	24	...
Tu	–	4	11	18	25	...
W	–	5	12	19	26	...
Th	–	6	13	20	27	...
F	–	7	14	21	28	...
Sa	1	8	15	22	29	...

OCTOBER						
S	..	–	7	14	21	28
M	..	1	8	15	22	29
Tu	..	2	9	16	23	30
W	..	3	10	17	24	31
Th	..	4	11	18	25	...
F	..	5	12	19	26	...
Sa	..	6	13	20	27	...

NOVEMBER						
S	..	–	4	11	18	25
M	..	–	5	12	19	26
Tu	..	–	6	13	20	27
W	..	–	7	14	21	28
Th	..	1	8	15	22	29
F	..	2	9	16	23	30
Sa	..	3	10	17	24	...

DECEMBER						
S	..	2	9	16	23	30
M	..	3	10	17	24	31
Tu	..	4	11	18	25	...
W	..	5	12	19	26	...
Th	..	6	13	20	27	...
F	..	7	14	21	28	...
Sa	1	8	15	22	29	...

PROMISE AND PERFORMANCE

LIBERAL GOVERNMENT, 1892-5:

Bills promised in Queen's Speeches	26
Whereof became law	6

UNIONIST GOVERNMENT, 1895-9:

Bills promised in Queen's Speeches	28
Whereof have become law	22

A GOODLY LIST.

The following are some of the more important measures which the present Unionist Government have passed through Parliament:—

WORKMEN'S COMPENSATION ACT.
CONCILIATION ACT.
MINES' ACT.
FOREIGN PRISON GOODS EXCLUSION ACT.
TRUCK ABOLITION ACT.
PUBLIC HEALTH (SCOTLAND) ACT.
LOCAL GOVERNMENT (IRELAND) ACT.
EDUCATION ACTS.
RAILWAY ACTS.
CRIMINAL EVIDENCE ACT.
PRISONS ACT.
HABITUAL DRUNKARDS' ACT.
NAVAL WORKS ACT.
PRIVATE LEGISLATION (SCOTLAND) ACT.
LONDON GOVERNMENT ACT.
SMALL HOUSES LOANS ACT.
TELEPHONE ACT.
SALE OF FOOD AND DRUGS ACT.
NIGER TERRITORIES' ACT.

NATIONAL DEBT REDUCTION.

	1886	1899
Debt	£745,000,000	£635,000,000
Population	36,313,000	40,559,000
Debt per head of population	£20, 10s. 4d.	£15, 13s. 1d.

THE NAVY AND THE NATION.

TWICE within the last two years the Navy has been our salvation. (1) Its overwhelming superiority prevented France going to war about Fashoda, and compelled her to give way. (2) It has enabled us, with perfect security against European intervention or invasion, to send a large army to redress the wrongs of our people in South Africa. The strength and efficiency of our Navy is due to the foresight and energy of the Unionist leaders, whose policy has doubled the fighting power of our Navy in the past twelve years.

SUCCESSFUL DIPLOMACY.

So long as we maintain a good understanding with Germany and the United States, our international position is secure. With both these countries we have had questions of serious difficulty in recent years. But, thanks to the skilful diplomacy of Lord Salisbury, not merely has any conflict been avoided, but our relations are now of a more cordial character with both countries than has been the case for many years; indeed, in regard to America, it may be said that our relations have never been so satisfactory as at present at any time since the War of Independence.

PRIVATE BILL LEGISLATION.

FOR many years the demand for local inquiries in Scotland for these Bills has agitated the country. Successive Ministries and Ministers have attempted to deal with the question, but always unsuccessfully. Now, however, Lord Balfour of Burleigh and the Lord Advocate have successfully grappled with it, and, cordially supported by their colleagues in the Government, they have given Scotland a reform which Scotland wanted.

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